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(Continued)

PROGRESS OF VERRUGA WORK WITH PHLEBOTOMUS VERRUCARUM T.

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The following is a brief abstract of the results to date from inoculations of laboratory animals with *Phlebotomus verrucarum* T. at the Verruga Laboratory in Chosica (near Lima), Peru. The temperatures given are all rectal and Centigrade. All weights are in grams. All dates are 1913.

It may be said by way of preface that Dr. R. P. Strong, of Harvard, assisted by others, has recently put forth the opinion that Barton's *x*-bodies are the causative organism of Oroya fever, and has bestowed on them the name *Bartonia bacilliformis;* that verruga eruption is caused by a virus present in the eruption; and that the two are separate pathologic entities. To this the writer of the present article does not agree; but the *x*-bodies in question, or what appear indistinguishable therefrom morphologically, are referred to herein as Bartonia bodies.

It is well to state that the Verruga Laboratory at Chosica is quite outside the limits of the verruga zones, the nearest known verruga locality being Santa Eulalia some three miles distant. The topography of the country lying between Santa Eulalia and Chosica, the unfailing strong winds in the Chosica valley, the heavy night fogs during the cool season, and the lack of sufficient rainfall during the warm season, all combine to preclude any chance of the disease reach-

ing Chosica, since these conditions are inimical to the establishment and persistence of the Phlebotomus in the vicinity.

Santa Eulalia, about 3,500 feet, marks the lower limits of the verruga zone of the Rimac valley, and Matucana, about 7,800 feet, marks its upper limits. The Phlebotomus has been found by the writer at both places, and at several intermediate points. It is most abundant at Verrugas Canyon, about 5,300 feet, being abroad there every night in the year. Practically all the Phlebotomus used in these experiments were brought from Verrugas Canyon.

Experiment I

Cebus capuchinus, male, 2 or 3 years old, from Peruvian montanya. Average temperature under 39°. Kept in laboratory from April 22 to October 10. Perfectly normal and healthy, blood normal. On October 10 he was taken to Verrugas Canyon and chained to a tree at east end of house next to stone wall from which issue the Phlebotomus in large numbers every night, and kept there continuously till November 6, when he was returned to the laboratory in Chosica. On many nights spent in Verrugas Canyon by the writer and his assistants, from July 9 to November 6, not a single bloodsucker of any description was seen flying other than the Phlebotomus, and the writer has personally spent the entire night in such search. It is thus quite certain that this monkey was not bitten by any culicid or other night-flying bloodsucker in addition to the Phlebotomus. Blood smear taken October 15 showed nothing. Smears taken November 12 and 18 showed Bartonia bodies in small number. Temperatures varied from 39.3° to over 43°, but no high temperature was long continued. Miliar eruption began to appear on orbits November 13, decreasing on November 17. Miliar sore appeared on back of left hand November 18, and one on outside of left foot at ankle. November 21 showed five bleeding miliar sores, being on left orbit, left hand, left elbow, and both feet, all having scabbed over the following day. For several days these were most typical, with exudation, exactly like miliar eruptive sores commonly seen on legs of human cases. The left orbit, left hand and elbow sores practically dried up November 28, the feet still remaining scabbed for some time thereafter. Later about five sores developed on the back and continued for over three weeks. This was evidently the acute type with miliar eruption.

Experiment II

Cebus capuchinus, male, about two years, from Peruvian montanya. Admitted to laboratory April 22 with the preceding. Average temperature under 39°. Normal weight about 4,500. Perfectly sound

and blood normal. Injected subcutaneously September 4 with 75 Phlebotomus in physiological solution. Marked leucocytosis shown in smears of September 5 to 7 inclusive, especially latter date, white cells becoming normal on September 8. Smears of September 6 and 7 show Bartonia bodies. September 5 to 8 the temperatures varied from 39.2° to 40.2° on latter date, and averaged .7° above normal for two weeks thereafter. September 6 the animal weighed only 3,900, was decidedly ill, thin, with no appetite. Weight gradually increased after that date, appetite improving on following days. No visible external sign of eruption has appeared. This seems a case of cutting short the disease by phagocytosis, at least to an extent, in an animal not particularly susceptible but rather resistant.

Experiment VI

Lepus cuniculus, male, about 1 year, brought to laboratory March 29 from Jauja, 11,000 feet. Temperature average under 39°. Normal weight 1,700. Healthy, blood normal. Kept in cage August 7 to 11 with nine living Phlebotomus, most of which died on second and third days. Injected subcutaneously August 8 with 21 Phlebotomus in physiological solution. August 9 to 14 temperatures varied from 38.4° to 39.5°, weights falling to 1,588 on latter date. Smear of August 11 shows Bartonia bodies and marked leucocytosis which continued till August 13, leucocytes becoming normal the next day. August 16 smear also shows Bartonia bodies, but white cells were normal. Temperature was below normal on that date, after which weights and temperatures approximated normal and no visible external eruption appeared. On October 16 the animal received a scrotal injection of a small quantity of virus from nodular verruga eruption of man. The result of latter inoculation was a small scabbed verruga at point of injection, persisting from November 4 to 26. This appears to be a case somewhat similar to No. II, the verruga organisms being largely phagocyted out of the system following the infection with Phlebotomus. That such course does not confer immunity is indicated by the localized verruga following the inoculation two months later with virus from man.

Experiment XV

Canis caraibicus, female, about 18 months, from Chosica. Admitted to laboratory April 24. Average temperature under 38.5°. Normal weight about 3,500. Perfectly sound, blood normal. Injected subcutaneously July 11 with 20 Phlebotomus in physiological solution. The course of this case up to July 19 is published in the *Journal of the American Medical Association* (Nov. 8, 1913). Nodular eruption on

feet appeared July 17, the animal having been decidedly ill the day before and showing Bartonia bodies in the blood. Temperatures did not rise appreciably, being less than a degree above normal average. Weights slightly lowered. Papules on feet receded and renewed, sometimes bleeding, up to August 29, when weight fell to 2,957 and eruption distinctly decreased in intensity, remaining so for some days. September 4 the extreme tips of both ear-lobes showed eruption, scabbed, bleeding more or less, of the excrescentic-nodular type, continuing on both ears till September 29, and on right ear till October 16 when it had nearly disappeared. Sections of ear tips and papules show portions with apparent histology of verruga eruption. On October 16 this dog received five separate subcutaneous injections, in distinct regions, of virus from nodular verrugas of man. Absolutely no result followed these five inoculations, no lesions forming at points of injection. This indicates immunity conferred by the Phlebotomus injection of July 11 followed by a generalized eruption. It is quite possible that internal eruption may also have ensued, as indicated by continued loss of weight and more or less pain in joints and body.

Experiment XVI

Canis caraïbicus, male, about 2 years, from Chosica. Admitted to laboratory April 24. Average temperature under 38.5°. Normal weight about 6,300. Sound, blood normal. This animal received five separate subcutaneous injections on September 19, 23, 25, 27, and October 12, with 80, 75, 107, 109 and 50 Phlebotomus respectively in physiological solution, the injections alternating between the two shoulders. Smears showed Bartonia bodies September 20 (22½ hours after first injection), September 25, and again October 14. They showed leucocytosis beginning September 27 and 28, increased September 29 and 30, white cells normal again October 1 and continuing so until October 13, when another increase was noted, which had disappeared next day. Polychromatophilia of the erythrocytes was evident September 21 to 25. Temperatures ran 37.7° to 40.6° from September 20 to October 7, but only rarely fell below 39° and were nearly always close to 40°. October 7 to 12 temperatures decreased some, going below normal on latter date and remaining so continuously till November 2, except only October 20 and 27. Weights gradually dropped to 5,808 September 28, with temperature of 40°, and remained under 6,000 to September 30 inclusive. Abscesses of considerable size formed at points of the five injections, but all were absorbed except the fifth which broke October 18. November 2 a nodular verruga suddenly formed on dorsa median line between shoulders, and increased in size during next two days, being of large size

with angular scabs on November 4 when it was excised. Another verruga at once began to form in its place, reaching good size November 10 and continuing with slight further growth to December 15 and later. A small typical nodular verruga formed November 20 to 22 on base of an ordinary wart which had sloughed on former date. This was on right chest and the verruga was excised November 22. Sections of these two excised verrugas show the identical histological structure of nodular verrugas from man. To sum up, this dog has shown decrease in weight, marked rise and fall of temperature, Bartonia bodies in blood, with spare leucocytosis and erythrocytic polychromatophilia, followed by what must be considered a generalized though meager eruption, as result of injection of over 400 Phlebotomus from Verrugas Canyon. Internal eruption may also have ensued in this case. This is the star injection experiment, and the one which has afforded the most convincing results.

Experiment XIX

Cavia cobaya, male, born in laboratory May 13 of parents from Jauja. Average temperature 38.5°. Average weight about 400. Perfectly healthy and blood normal. Placed in cage July 29 with two living Phlebotomus, to which were added six from Matucana on August 2, being removed finally from cage August 7 on death of the last Phlebotomus. Smears of August 7 and 16 show Bartonia bodies. A marked lymphocytosis was evident August 8 and 9, and again August 19 and 20, unusual numbers of small lymphocytes showing in the smears, being normal on other dates. Temperatures showed an appreciable continued rise for six weeks after August 2, being practically all (a. m. and p. m.) between 39° and 40°. No visible external eruption followed. This is another case of an animal with small susceptibility phagocyting the organisms and showing no external eruption. The infection was undoubtedly slight.

Experiment XXII

Cavia cobaya, female, born in laboratory May 18 of parents from Jauja. Normal temperature 38.5°. Placed in cage July 24 with 12 living Phlebotomus, and left there till July 29 when it died, 2 of the Phlebotomus being still alive. Smear taken July 28, at 10.15 a. m., shows Bartonia bodies, as does also smear of autopsy thoracic-cavity blood. Autopsy liver, spleen, cord and lung smears show interesting conditions which require further study. Temperature at 9.30 a. m., July 28, was 39.8°. That this pig died from the infection induced by the bites of the Phlebotomus is not at all certain. Yet the temperature was high the day before, and autopsy of the digestive tract disclosed nothing abnormal.

Experiment XXIII

Canis caraibicus, male, about 5 months, from Chosica. Admitted to laboratory July 25. Average temperature under 38.5°. Normal weight about 2,900. Animal perfectly sound. Smear showed blood normal before experiment. Injected subcutaneously in right shoulder July 25 with 25 Phlebotomus in physiological solution. At 5 p. m., six hours after injection, temperature was 40°. Smears of July 27 (48 hours after injection) and August 20 show Bartonia bodies. Temperatures averaged a little above normal from July 25 to August 2, going from 39.3° to 40° during the first three days. Throughout August they were usually below normal, rarely above, after which they gradually rose to around normal. Weight July 26 was 2,041, and varied through August from 2,496 to 2,839, gradually rising. Leucytosis showed in smear of July 28. Small sores appeared suddenly on ear-lobes August 23, these bearing considerable resemblance to miliar eruptive sores, but only slightly raised. They continued on the ear-lobes, inside and out, increasing, drying, decreasing, and coming anew, until September 16 when most of the scabs had dropped. By October 6 there was no trace of the scars. Sections of these ear papules show a strong approximation to verruga histological structure. On October 12 injected subcutaneously in right shoulder with 50 Phlebotomus in physiological solution. Temperatures averaged but slightly above normal for three weeks following this last injection, but at times passed 39° and 40°. Weight increased gradually, and smears apparently showed neither Bartonia bodies nor anything abnormal. December 2, however, a small, hard, raised, uncolored nodule appeared suddenly on outer base of left foreleg, and by December 5 had become a typical hard nodular verruga to all appearances. It was excised and sectioned for study. The sections show a typical verruga histology. If the ear sores above described were verruga, as is probable, they did not confer immunity in this dog.

Experiment XXV

Canis criollus (tan-haired creole dog), male, about 6 months, from Chosica. Admitted to laboratory August 16. Average temperature under 38.5°. Normal weight about 3,800. Healthy, and smear showed blood normal before experiment. Placed in cage September 18 with 35 living Phlebotomus, to which were added 25 on September 23; 30 more on September 25; and 30 more on September 27, all from Verrugas Canyon. Removed from cage September 29, the Phlebotomus being practically all dead, notwithstanding the daily envelopment of the cage with wet cloths in the effort to prolong their lives, and the confinement of the dog between two wire desk baskets to prevent free-

dom of movement. Smears of September 26, 29, October 4 and 10 show Bartonia bodies. Smears also show leucocytosis beginning September 18 and gradually increasing to September 24, with a lapse to normal September 30 to October 9, appearing again slightly till October 14. Temperature average for thirty days following September 18 was 39°, reaching 40° on September 26, 40.6° on October 9, and remaining continuously close to 40° from September 23 to October 2. Weights showed quite steady gain from 3,472 on September 19 to 4,200 on October 14. No visible external eruption has yet appeared. This seems another case of a resistant animal phagocyting the verruga organisms. The experiment is the most ambitious one that it was possible to try at that season with the living Phlebotomus.

Experiment XXVI

Canis caraibicus, male, about 2 years, from Chosica. Admitted to laboratory August 18. Average temperature under 38.5°. Normal weight about 7,000. Very healthy, sound, smear showed blood normal before experiment. Injected subcutaneously September 4 with 50 Phlebotomus in physiological solution. Smear of September 7 shows Bartonia bodies. Leucocytosis is shown in smear of September 13. Temperature averaged 39.5° for the ten days succeeding September 6, reaching 40° on September 10 and 14, and being close to 40° from September 9 to 18. Weights showed fall only on September 7 and 8 of 300, and September 18 of 700, with these exceptions rising quite steadily from 6,550 on September 5 to 6,750 on September 17, but passing 7,000 on September 10 and 13. Up to October 16 dog had been quite normal and no external eruption had appeared. On latter date injected subcutaneously in right shoulder with strong dose of virus from nodular verrugas of man. This injection produced a marked effect, animal becoming dangerously ill and weak, with great pain and tenderness in right shoulder, where an immense abscess formed at point of injection involving the entire scapular region, these conditions continuing from October 18 to 23, when the abscess broke, and the dangerous effects persisting for some days after. Temperatures averaged only slightly above normal for the first ten days (.2° to .3° above), and below normal for the succeeding thirty days (.1° to .5° below). The raw surface resulting from breaking of abscess gradually healed, the edges of the lesion showing verrugas from November 2 to 13, these being constantly destroyed by the never-ending action of the animal's tongue. November 20 a small verruga had formed on forehead, and a larger one on outside of tip of right ear-lobe, both of which gradually increased to November 26 and 27 when they sloughed. November 22 showed eruptive scabbing on left ear-lobe and left jowl, these continu-

ing off and on till December 15, and later, with eruption lesions appearing on throat December 1. Smear of October 17, taken 24 hours after the virus injection, showed Bartonia bodies and leucocytosis. It may be stated here that the abscess in this and other cases was not due to defective technique, aseptic methods having been employed in all cases. The present very large abscess was doubtless due to septic material from the decomposition of tissues within the unbroken verrugas from which the virus was taken. This experiment indicates a certain degree of control of the infection from the Phlebotomus injection, no immunity being conferred; but inability to control the infection from the virus injection, which resulted in a generalized eruption, as distinguished from a purely localized one at point of injection.

Experiment XXVII

Canis caraibicus, male, about 18 months, from Lima. Admitted to laboratory August 28. Healthy, blood normal. Injected subcutaneously with 39 Phlebotomus in physiological solution, August 29, at 11.30 a. m. Temperatures rose on succeeding dates, reaching 39.5° on September 2. Weights decreased steadily from 3,575 on August 30 to 3,357 on September 3, except 3,646 and 3,605 on September 1 and 2. Smear of August 31, 46 hours after injection, shows Bartonia bodies rather numerously, also some leucocytosis. Dog very sick and weak August 30 to September 2, without appetite August 30 and 31. Chloroformed September 3 and various tissues preserved for sectioning.

Experiment XXVIII

Canis caraibicus, male, about ten months, from Chosica. Admitted to laboratory September 10. Average temperature well under 39°. Normal weight about 4,500. Healthy, blood normal before experiment. Testicular injection given at 10.30 a. m., October 5 with 100 Phlebotomus in physiological solution. Smear of October 6, taken at 8 a. m., shows Bartonia bodies, as do those of October 8 and 9. Weights decreased but temperatures remained practically normal. Abscess formed in testicle and broke October 9. Leucocytosis appeared in smears of October 9 to 11. Chloroformed dog October 12 and preserved tissues for sectioning.

This concludes the experiments to date. The writer wishes to acknowledge the valuable service rendered by his assistant on this work, Mr. George E. Nicholson. Unfortunately Mr. Nicholson contracted the disease as the result of being bitten by the Phlebotomus on the night of September 17 at Verrugas Canyon, an account of which was sent to *Entomological News* (vol. XXV, p. 40). His fever continued

for three weeks, during which time the Bartonia bodies were numerous, after which his temperature dropped below normal and remained so for about ten days, pains in the joints being prominent during this period. He received an intravenous injection of neosalvarsan on November 10, being about 30 cc. He has had no fever since November 15, nor has his blood shown Bartonia bodies. Eruption began to show December 24, and he has nearly regained his normal condition, the only symptoms persisting being reduced weight and somewhat reduced physical endurance.

As the result of the experience gained in the above experiments, hairless dogs appear to be the most satisfactory laboratory animals for verruga experimentation, at least in Peru. They are abundant and easily obtained, not too resistant, and the eruption can readily be seen upon them and photographed. Cebus monkeys are about equally susceptible, but very difficult to obtain and also to handle, while their thick coat of hair makes the finding and photographing of the eruption quite inconvenient. Rabbits are moderately susceptible, and guinea pigs rather less so. All of these animals appear more resistant to verruga than man.

The solution used in the injections was a citrated normal saline solution (Kronecker's artificial serum of Vogt and Yung, citrated). The Phlebotomus were placed on a glass slide with a little of this and crushed with a glass rod, the action being continued until the gnats were so finely ground up that all would pass through the needle of the syringe. The amount of solution used for an injection was usually 1 cc. In the case of the virus injections, the contents of the verrugas were squeezed out in the same solution and injected.

The writer calls especial attention to the finding of the Bartonia bodies, or of what seem morphologically identical with them, in the blood of laboratory animals. This is the first series of experiments that have shown this condition. Previous investigators who have succeeded in transmitting localized verruga to laboratory animals by injection of human virus uniformly claim that they have been unable to find Bartonia bodies in the blood, and that the characteristic blood changes known for human cases are absent in such animals. Whatever may be the true explanation of this, the writer wishes to emphasize the necessity for prolonged search in studies of Bartonia in the lower animals. It may often be necessary to search a single smear two or three hours, a half day or a whole day, in order to find a Bartonia body that may be present in it; and even this length of time may be insufficient. That this work is tedious in the extreme goes without saying, but when one realizes that a half dozen or even half hundred smears taken from an animal actually carrying Bartonia bodies in its blood at the time

may fail to contain a single one of these bodies, the necessity for prolonged search is apparent. The writer finds that the smears from his laboratory animals have never shown any approach to the abundance of the x-bodies often exhibited by smears from human cases. While the bodies are present in these animals, they usually exist in extremely small number compared with the average of human cases. An important point also is to take smears at least twice daily from the animal immediately following inoculation. The bodies may usually be found during the first three days. After the eruption has begun to appear, it is quite useless to look for them.

Despite repeated and persistent search from July to October, the early stages of the Phlebotomus have not yet been discovered. It has thus not been possible to attempt the rearing or breeding of them for infection experiments. While no doubt this could be accomplished with unlimited facilities, it is not at all necessary to the complete demonstration of the transmission, already secured, and its realisation is not warranted by the conditions. At best it would probably be one of the most difficult entomological feats ever attempted.

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December 31, 1913.

THE RELATION OF VARIATION IN THE NUMBER OF LARVAL STAGES TO SEX DEVELOPMENT IN THE GIPSY MOTH

By F. H. Mosher and R. T. Webber

During the season of 1912 a series of experiments on food plants was carried on at the Gipsy Moth Laboratory at Melrose Highlands, Mass. The main object of these experiments was to test the feeding of the gipsy moth on various plants; the results to be made use of in the thinning out of woodlands where this system of control could be adopted. Again, the results and data thus obtained could be used in comparison with this work in the field.

The food plants chosen for these experiments included those trees and shrubs which predominate throughout the infested territory. Some of the species selected were the oaks, hickories, maples and birches. There were many others of more or less importance, including some of the conifers, and such shrubs as witchhazel, cornus, barberry, etc., in all about fifty different species.

As the experiments neared completion, it became apparent that there was a difference in the stages in which the larvæ spun up previous to pupating, and upon close examination this peculiarity seemed to be more or less constant. A careful inspection of pupæ indicated that those larvæ that pupated in the fifth stage produced male moths, while those having a sixth stage developed females.

As there was little data at hand to show the constancy of this variation the results were noted and conclusions reserved until a later period.

The following year, 1913, the feeding experiments were repeated and the same method used as during the previous year, except that a more careful system of record keeping was devised and more attention was paid to the stage and pupation of caterpillars.

Method of Conducting Food Experiments

Under the single head of food plant experiments were grouped the following sub-experiments:

(1) The continuation of last year's experiments in which the eggs laid by the parent moth reared on a single food plant, were hatched and their progeny placed on the same food plant as last year.

(2) The combination food plant experiments in which the newly hatched larvæ were placed on a combination of foods and reared in that manner.

(3) Straight food plant experiments in which newly hatched larvæ were reared on a single food plant.

The larvæ used in the straight and combination feeding experiments were obtained from a newly infested locality at Barre, Mass. The colony is situated outside the generally infested territory and the larvæ were in a supposedly healthy condition.

In order that larvæ might be reared under the most natural conditions, all of the experiments were conducted in a large outdoor insectary.

There were about 174 trays used in the combined experiments which necessitated the use of about 17,000 caterpillars.

The eggs were hatched under natural conditions and 100 of the young larvae, as nearly uniform in size as possible, were placed in trays prepared for them.

The trays used in these experiments are a modification of the Fiske tray. They are of two sizes, one for the newly hatched larvæ, 6″ x 7″ x2″; and those used for the older larvæ, 12½″ x 12½″ x 2½″. The trays used in 1912 were wood frame with cloth bottom, but as considerable difficulty was experienced by the young larvæ in crawling over the cloth, a paraffined paper tray was substituted in 1913, and proved to be a vast improvement over the other. This paper tray when folded fitted snugly into wooden trays previously used. A band of tanglefoot 1 inch wide was placed on the upper inside margin of the trays to prevent the larvæ from escaping and the intrusion of others.

The food was kept fresh by placing the cut end or twigs bearing foliage in a receptacle filled with water. A specimen vial about 1 inch square and 3½ inches long and with the neck projecting at an angle of 45° was used for this purpose. The stem of foliage selected for food was thrust through a hole in a cork stopper which was inserted in the vial of water. By using a vial of this description the food was never in contact with sides of trays but lay evenly distributed across the center, thereby preventing all opportunity for escape of larvæ.

Each tray was inspected daily and a note made of the number of larvæ in each stage. The dead or dying caterpillars were removed and the tray cleaned of all excrement and other refuse. If at any time there was an excessive number of dead larvæ the living ones were transferred to a fresh tray. In this way sanitary conditions were maintained. A careful and complete record was also kept of the amount of food consumed by the larvæ and a note made of any changes affecting them.

The results of experiments in regard to sexual variation of larvæ confirmed those of last year and established the fact that the variation is constant so far as these experiments go. Of a few thousand larvæ that were under observation in the later stages, 560 transformed into chrysalids. Three hundred and twenty-five of these were males and

pupated in the fifth stage, while the remaining 235 passed into the sixth stage and developed female pupæ.

Available information bearing on this subject in other species is limited, although Doctor Dyar as quoted in Packard's text-book, p. 618, says that the average number of molts of lepidopterous larvæ is five, but six or seven stages are not infrequent. In rearing larvæ of *Hemerocampa* (*Orgyia*) *gulosa* Hy. Ed., he found that the males molt three or four times; the females always four. He also notes in *Psyche*, Vol. 5, p. 422, 1890, a somewhat similar variation in *Hemerocampa* (*Orgyia*) *definita* Pack. In this species the female larvæ require one more stage than the male.

In the First Annual Report of the State Entomologist of Missouri, 1869, p. 145, there is an account of Professor Riley's observations using larvæ of *Hemerocampa* (*Orgyia*) *leucostigma* S. & A., which was as follows: "About the middle of the month of May these eggs began to hatch. . . . Six days after the second molt, the third molt takes place with but little change in the appearance of the caterpillar. Further than that, the different colors become more bright and distinct, and different tufts still larger. Up to this time all the individuals of a brood had been alike, and of a size, so that it was impossible to distinguish the sexes. Six days from the third molt, however, the males measured not quite ¾ inch, and begin to spin their cocoons, while the females undergo a fourth molt about this time, and in about six days more they also spin up having acquired twice the size of the male when he spun up."

There seems to be little doubt but that the female larvæ of this species require an additional stage under normal conditions, but when subject to unnatural conditions this rule may not hold. That the larvæ of this species may vary considerably when fed sparingly is evidenced by the result of Miss Murtfeldt's experiment, which was carried on under the direction of Doctor Riley. In rearing these caterpillars and feeding them only enough to sustain life both males and females molted four times.[1]

On several occasions the scarcity of certain foods necessitated the stinting of caterpillars used in our experiments, but regardless of this fact the females passed through an additional larval stage.

In the March number of the *Entomologists Monthly Magazine*, 1887, V. 23, p. 224, there is an article by Dr. T. A. Chapman on the molting of *Notolophus* (*Orgyia*) *antiqua* Linn., and on rearing its larvæ he says: "The variability of molting occurs in the later stages. When we come to inquire into the significance of this variability, we meet at once with a very decided fact, and that is, that those that molt only three

[1] The Amer. Nat., Sept. 1873, V. 7, No. 9, p. 513.

times always produce male moths, that those that molt five times always produce female moths, those that molt four times produce both.

"It would thus appear that in *Notolophus* (*Orgyia*) *antiqua* Linn., the female molts one time more than the male, a circumstance that I have not seen noticed as occurring in any species, and that further the molts may vary by one."

The results obtained by Doctor Chapman's experiments using larvæ of *Notolophus* (*Orgyia*) *antiqua* Linn. are corroborated by Mr. J. Hillins,[1] who conducted an experiment using larvæ of the same species. Mr. Hillins found that one male molted three times; one female molted five times, and one male and one female molted four times.

The variation in the pupation of another species is noted by Prof. J. A. Lintner in his First Annual Report on the Insects of New York in 1882. In the lappet moth, *Tolype laricis* Fitch., he found that the males molted but three times while the females went through an additional stage.

Prof. C. H. Fernald's experiments using larvæ of the gipsy moth are noted in the Report on the Gipsy Moth written in 1896. Out of a batch of 55 newly hatched larvæ used in this experiment, 52 completed their transformations with the following results: 1 female molted six times, 29 females molted five times, and 9 females molted four times; 7 males molted five times, and 6 males molted four times.

According to the experiment just related there was no variation whatever in the larval form as to sex of this insect, and, moreover, another distinct stage was observed.

Morgan's "Experimental Zoölogy" has an interesting account by Pictet pertaining to the external appearance of some species of lepidopterous larvæ in regard to sex. In one instance he states (page 43), that in the larval form of *Porthetria* (*Ocneria*) *dispar*, the sexual dimorphism is marked, but adds that this only occurs in the fully formed caterpillars. In another paragraph he says, "The caterpillars of *P. dispar* normally transform into chrysalids after the sixth molt."

The results of these experiments by Pictet are at variance with our own in numerous ways. We have never observed any uniform difference between the two sexes in the larval form, except in the size of the head and body. Our experiments would indicate that only female pupæ developed from sixth stage larvæ.

In the sixth stage the velvety black stripes running vertically on each side of the clypeus are wider and more distinct but the size of the head although varying somewhat is considerably larger than in the fifth stage.

[1] Entom. Month. Mag., 1881, V. 18, p. 86.

When caterpillars of this species prepare to pupate they cast their skins with the heads attached and these exuviæ are usually found with the pupæ suspended in silk spun prior to transforming. As the pupa and exuvia lie in close proximity to one another it is quite easy to distinguish the larval stage of the molted skin.

The results secured from larvæ reared in confinement were checked by observations in the field. Localities were selected with reference to their elevation, infestation, and food abundance.

At Wellesley, Mass., where the foliage was completely stripped, a careful inspection was made. Over fifty masses of pupæ were examined and while the percentage of female pupæ was small, a sufficient number was secured to verify the tray results. Fifteen sixth stage molted skins were attached to as many female pupæ, while 35 fifth stage caterpillars had transformed to male pupæ.

A larval collection was also made at this location. Eighty-two caterpillars all of which were in the prepupal stage were collected and brought to the laboratory. The stage of these was then determined and the fifth and sixth stage larvæ placed in separate trays in the insectary. Of the 56 fifth stage larvæ placed in one tray, 6 died of parasitism, 4 of disease, and the remaining 46 produced male pupæ. There were 26 sixth stage larvæ in the other tray, 3 died of parasitism, and the rest developed females. Although supplied with food the larvæ ate but little and all excepting those killed by parasites pupated within 48 hours.

At Salem, N. H., in a lightly infested area of mixed growth the results were practically the same. A few sixth stage molted skins were found attached to female pupæ and an equal number of fifth stage molted skins were closely intermingled with masses of male pupæ.

The last inspection was made at Allenstown, N. H. This infestation was of medium severity and located on a comparatively high elevation. As before several masses of pupæ were examined; the results of which were as follows: one mass contained 10 males and 6 female pupæ; one 14 males and 7 females, and another 8 males and 5 females. One-half mile from this point an inspection was made in a clear stand of pine lying adjacent to a mixed growth. Here several masses of pupæ were examined and the results confirmed the former observations.

It is not the purpose of this paper to dispute the conclusions reached by former investigators of this subject, nor do we claim that the gipsy moth larvæ do not sometimes pass through a seventh stage. We have never found it in our tray work and moreover the development of male and female pupæ from fifth and sixth stage larvæ has been constant in all our experiments. There can be no doubt but that the gipsy

moth is changing or has changed its habits in this country. Sixteen or seventeen years ago, when the Report on the Gipsy Moth was published by Forbush and Fernald, elm and barberry and many other trees and shrubs were considered very favorable food plants. In obscure locations where a slight infestation was detected and barberry was present the egg masses were usually found on that species, but this is seldom the case today, and this shrub is rarely infested. That the insect itself is less hardy than in the past is a surety and it is far more susceptible to disease. Again, there is a perceptible decrease in the average number of eggs laid by female moths except in newly infested territory, and as a rule full-grown larvæ secured at the present time are seldom as large as specimens taken at the time the above-mentioned report was published. These conditions may have some bearing on the results secured in our investigations from those published fifteen years ago.

NOTES ON FOREST INSECTS

By E. P. Felt, *Albany, N. Y.*

Both 1912 and 1913 were remarkable because of the abundance of the forest tent caterpillar, *Malacosoma disstria* Hubn. Last season it stripped oaks on Long Island, sugar maples in the Hudson and St. Lawrence valleys, and in certain Adirondack sections extensive areas of poplar were defoliated, a marked preference being shown for the tops of the taller trees. Pin or bird cherry, cornus and elms were partly stripped when near defoliated poplars, while red maple, birch, pine, balsam, spruce and hemlock were practically untouched. This is the second outbreak of the forest tent caterpillar in fifteen years, and in each instance there has been a superabundance of the apple tent caterpillar, *Malacosoma americana* Fabr. These species are so closely allied and are preyed upon to so large an extent by the same natural enemies, that it seems reasonable to expect synchronous outbreaks. We are of the opinion that insect parasites of the larvæ are among the more important controlling agents, though the increase in New York State, of injuries by leaf-feeding caterpillars in recent years suggests that the observed reduction in bird life during the past two decades may also have an important bearing on the problem.

The territory in the immediate vicinity of New York City has suffered greatly from the activity of a number of borers. The spotted hemlock borer, *Melanophila fulvoguttata* Harr., has destroyed many highly valued hemlocks; the two-lined chestnut borer, *Agrilus bilineatus* Weber, is killing the oaks, while the hickory bark beetle,

Eccoptogaster quadrispinosa Say, has swept out of existence thousands of hickories. It is well known that comparatively minor factors may turn the balance in favor of or against a destructive insect, and in connection with the above mentioned depredations we have looked for some general cause.

The outbreak by the hickory bark beetle in New York City and vicinity began about 1908, and an examination of the weather bureau records of that locality show an interesting condition. From 1906 to 1912 inclusive, there has been a deficient rainfall, except for 1907, at which time there was an excess of only half an inch. The total deficiency during this period amounted to 28.56 inches. The most marked deficiency for that period was in 1910, with a precipitation 8.75 inches below the normal, a reduction of approximately one-fifth. A scrutiny of the monthly precipitation shows that in 1906 the scarcity of rainfall occurred mostly from June to September, there being during these months from an inch to nearly an inch and a half less than the normal. The next year, 1907, although there was a slight increase in the annual rainfall, there was a considerable shortage for the months of July and August, this amounting respectively, to 3.36 and 2.05 inches. In 1908 there was a shortage of 1.56, 1.99 and 1.79 inches for the months of June, September and October, respectively. In 1909 there was a scarcity of rain during May, June and July, amounting respectively, to 1.46, .09 and 2.56 inches, there being an excess in August of 3.41 inches and a shortage in September of .93 inches. In 1910 there was a shortage in July, August and September amounting respectively, to 4.31, 2.40 and 2.16 inches with a slight excess in June of 1.84 inches. In 1911 there was a deficient rainfall in May, July and September amounting respectively, to 2.27, 2.99 and 2.08 inches, while in 1912 the deficiency from June to September, inclusive, was 2.09, 1.28, 1.76 and .21 inches for the four months in the order named.

Although the deficiency during this period was not as a whole very excessive, it will be noted that it was progressive and that the shrinkage in rainfall almost invariably came during the growing months and at times most likely to affect vegetation adversely. The general result in this region was abundantly evidenced by the unfavorable condition of the trees throughout the section, this being particularly marked in 1910 and 1911 and was accompanied by an abnormal scarcity of water. A number of trees, particularly soft maples and others standing in naturally moist, low localities, died, the major cause probably being scarcity of moisture.

With the above facts in mind it seems reasonable to believe that these unfavorable climatic conditions may have reacted upon the trees, reducing their normal resistance considerably and resulting in

conditions which were extremely favorable to the multiplication of bark borers. We would not be understood as holding that the above data were conclusive, though they may be very suggestive. It is obviously impractical at the present time to safeguard against drought, at least upon any extended scale, though the time may come when such data as that given above can be used to advantage in urging more comprehensive measures for the conservation of moisture and indirectly the control of certain classes of insect outbreaks.

The extensive plantings of white pines in the reforestation work of recent years in New York has produced conditions very favorable for injury by the white pine weevil, *Pissodes strobi* Peck. A number of requests for assistance in combating this pest were received, and the past season it was possible to carry out some coöperative experiments at Cooperstown which are at least worthy of record. In cooperation with Mr. Waldo C. Johnston of Cooperstown, the efficacy of hand collecting was tried on an area of fifty acres set with about 60,000 pines, the trees being approximately two to three feet high. Moderately large insect nets were used, the men simply tapping the plants so as to jar off the insects. The work was started a little late, namely, about May 21, and the trees carefully collected over four times at intervals of approximately four or five days. At the outset two to four weevils were caught per tree and toward the last only one or two insects per row of probably 400 trees were to be obtained. The cost of these four collections amounted to $64 or only $1.28 per acre. An examination, July 8, resulted in our not being able to find any weevils. It is probable that three collectings, particularly if the first was a little earlier, namely, in the first or second week in May and the other two at about ten-day intervals, would have resulted in capturing most of the weevils at less expense. There is no reason why, with improved devices, the cost of this operation could not be materially lowered. The fact that adults may live two or even three years and deposit eggs each season is a potent reason why collecting is more desirable than the destruction of infested shoots.

The above, taken in connection with experience of more than a decade ago, which showed that systematic collecting from a small group of pines, under what might be considered average woodland conditions, resulted in practical immunity from the pine weevil for a period of at least five years, leads us to believe that this method is worthy of a most thorough test.

ENTOMOLOGICAL WORK IN MISSOURI

By LEONARD HASEMAN, *Department of Entomology, University of Missouri*

All are familiar with the able work of Riley so well described and illustrated in his memorable Missouri Reports. This work was in large part practical and being in a new field was largely original. Even at the present time his illustrations and more technical descriptions are made use of. Unfortunately Missouri and the Middle West was not then able to fully appreciate the value of his work, and after nine years it was discontinued and by the farmer largely forgotten. Comparatively few of the older Missourians now remember him and his work, though entomologists will not soon forget him.

His work as state entomologist was under the supervision of the State Board of Agriculture with headquarters at St. Louis, Mo., and after it was discontinued nothing was done in this state to control the insect pests until this department was established in 1895. At that time Stedman was appointed head of the department and an effort was made to investigate and improve entomological conditions in the state. Some headway was made, but the state is a large one and conditions were favorable for the work of insects and not always favorable for the work of control, so that from year to year conditions clearly grew worse. Funds were scarce in the early days, help difficult to get and such a thing as legal authority to control pests was unknown in the state. For the first few years after the work of this department began, a special effort was made to reach the farmer in a popular way, and while some little original work was done it was not of a technical nature. Agricultural conditions generally had materially improved since Riley began work here, so Stedman had a much better opportunity to reach the farmers and secure their coöperation. He began his work just after the San José scale was introduced into the state and while efforts were made to check it, they were met with lack of support and means, and consequently with failure. Had this department at that time done nothing more than stamp out this pest in the dozen or so orchards where it was then found, it would have far more than justified its existence. Since that time this pest has cost the state thousands of dollars, and will continue to cost it even more.

The writer has had charge of the entomological work here since 1910 and has found some of the original handicaps still existing. Lack of interest in insect control, and with it lack of support and assistance have always been a serious drawback in Missouri. This is being felt much less now than in former years though we need a dozen men in place of two to cope with the entomological conditions as they are now found in this state.

Since taking charge of the work the writer has attempted to take up those particular pests or groups of pests which are of greatest importance and which have required special study. So far our attention has been directed mostly to the smaller projects which have not required continuous observations extending over a period of several years. Such projects have been out of question, but we are hoping to be able in the near future to undertake some of these larger lines of work. In recent years the orchard insects have been given most attention since there are so many of them and the fruit growers are by no means familiar with them and the methods of control. It should be said that the Missouri horticulturist is far behind the general farmer and stock man as regards up-to-date scientific methods. They have never gotten together for the improvement of horticultural conditions as the other men have. This is well shown by their failure to secure adequate legislation for the improvement of horticulture until the last legislature. It is hoped, however, that the interest they have shown in securing this state aid is a true sign that they are awakening to the horticultural needs and that they will give every assistance to the uplifting of this badly neglected industry in Missouri.

In connection with the carrying out of the horticultural inspection law provision is made for educational work, and if it is possible to reach the horticulturists at all we should do so through this work. A keen interest is being shown in this new work and the prospects, for accomplishing something worth while for Missouri horticulture, are bright. In attempting to get this new line of work in operation this year most of the experiment station projects had to be neglected so that we have made but little progress with them this year. It was thought, however, that the opportunities opened by this new work would warrant the temporary neglect of the investigation work.

The work of this department at present covers the regular instruction in the university, which includes three or four classes each semester and from one hundred and twenty-five to one hundred and fifty students; the experiment station projects with the various insect pests and groups of pests affecting agriculture and the nursery inspection work which has been taken up in real earnest this year. These various lines of work are handled by the writer and one assistant or rather they attempt to handle them. We feel that we are making some headway, though it seems slow at times, and we are often inclined to envy those in other states who are able to concentrate all their efforts on a certain project and when finished turn to something else.

One important but much neglected line of entomological work in this state is the improvement of conditions in bee-keeping. The state has done almost nothing to improve conditions and the growing

demand for help is becoming very pronounced. This department has taken up the subject and is offering courses in bee-keeping and is undertaking investigations of problems of practical value to bee-keepers. The state has an apiary inspection law which is under the supervision of the State Board of Agriculture, but inadequate funds are provided and the work is therefore badly neglected. The experiment station is undertaking coöperative work with a view of lending some assistance to this industry.

In the future it shall be the aim of the writer to continue to expand the work of this department to meet the various new demands made on it, and with this increase of work it is hoped more help will be added so that we can do more and better work in Missouri. The appointment of an entomologist at the fruit experiment station in southern Missouri will help out, but there is still room for more entomologists. The field for practical as well as technical work here is unsurpassed, and it is a pleasure to labor under such conditions even with the small means at one's disposal. The state grows cotton in the south, corn and wheat in the north, and fruit everywhere; it has swamp, prairie and mountainous conditions with a varied fauna and flora scarcely touched by scientific students and as yet but slightly affected by the economic entomologist.

AN INCIDENT IN THE SEARCH FOR FOREIGN GIPSY MOTH PARASITES

By L. O. Howard

At a joint meeting of the Entomological Society of America and Section F of the A. A. A. S., held at Atlanta December 31, the writer read a paper on present conditions of the imported gipsy moth parasites in the course of which he laid aside his manuscript for a moment to tell an anecdote which he thought illustrated in a capital way, not only the difficulties to be met with in the field in a foreign country, but also the necessity not only for a thorough knowledge of the subject, but for imagination, fertility of resource, persistency, and energy on the part of the investigator, if the best results are to be reached.

After the meeting, and in fact during the discussion of the paper, several persons present urged me to write this story for publication in the Journal. I am afraid that Mr. Fiske would not like me to do it, but he is out in Africa at present and I cannot well wait for his permission. I think that Doctor Fernald and the others who asked me to write the story for publication can make such good use of it in their teaching work that I shall overlook Fiske's possible objections, and so here is the story about as I told it. It was *apropos* to a mention of the present condition in this country of *Limnerium disparidis*.

Down to the summer of 1911, this interesting and probably important parasite of the gipsy moth larva had been found only in Russia, and only about from forty to fifty specimens had been received, although it had received the attention of Pospielow in the early days and of Kincaid in his later journey to Russia. It is one of the species whose cocoon hangs suspended by a silken thread for a longer or shorter time, and it had been the contention of W. F. Fiske that the reason more were not found was that the thread breaks sooner or later and the cocoon drops to the ground and is only to be found on the surface of the ground.

On June 15, 1911, Fiske found himself in the middle of a forest at Gioia Tauro, Sicily, where he was studying the results of parasitism following a destructive outbreak of the gipsy moth, and, examining the remains of the caterpillars in an effort to tell just which parasite has killed them, his attention was continually attracted to larvæ hanging by their hind legs much as do those attacked by the wilt disease, with their bodies containing a few drops of blackish fluid. It was not wilt, he was certain from the first, and by tracing the various stages of decomposition backwards he was able to associate it with parasitism by Tachinids. Mingled with these dead larvæ were a number of others pellucid in appearance, looking much like brown-tail caterpillars killed by certain species of Apanteles. He puzzled over the phenomenon for a moment until, with a burst of incredulous enlightenment, he hit upon the solution. Holding his forceps exactly beneath such a larva, he let them drop to the ground, and at the exact spot where they struck, fully exposed, was a fine fresh cocoon of the long sought for and constantly despaired of Russian Limnerium, which, as above stated, was not known to exist outside of Russia. The experiment was repeated again and again with other caterpillars and in every instance with satisfactory results. In the afternoon of the same day, in another forest, he found the parasite much more abundant. In seven minutes he collected fifty on a bit of hard trodden path where all that fell were exposed, and a little bit to one side beneath an especially large and leafy tree he collected twenty-five from approximately one square yard of surface.

In the evening he talked the matter over with his native assistant and interpreter. He asked him to make a formal call on the mayor of the village; to present his compliments and tell him that Mr. Fiske would be pleased to call on him in person, but that he was not expert in the Italian language; that he desired to send the children of the commune into the public forest for the purpose of collecting a quantity of insects which abounded there and for which he had a particular use, and that he wanted to find some responsible person recommended by

the mayor who could be prevailed upon to receive these cocoons and pay for them at the rate of one centesimo each and forward them to Fiske at Portici. The assistant objected. He said it was not good form to call on the mayor in this unceremonious way and he refused to do it; so they finally compromised on the assessor. Again there were objections, but presently the assistant went, and came back with a queer look on his face. He had visited the assessor, it appeared, but the latter was very much inclined to think that he had either an idiot or a madman to deal with, but he said he would see the forest guards and see if there would likely be anything out of the way in allowing them to take advantage of such an offer.

The next morning about six o'clock two forest guards, two children, and a number of dogs proceeded with them to the forest where he gave them a demonstration of what he wanted. At first it was a flat failure. The guards could not find any cocoons themselves, nor could the boys, but by working hard himself and showing the boys where the cocoons lay he succeeded in getting them to pick up ten each, and rewarded them each with a couple of *soldi*. This livened things up a bit. The guards still could not find the cocoons, but the boys were beginning to see light, and before long they began to collect them in some numbers and kept Fiske fairly busy counting them and paying over *soldi*. The guards watched the transfer in growing amazement and enthusiasm, and at the end of an hour they all went back to town, the boys with about three *lire* between them and Fiske with three hundred parasite cocoons.

The guards stated to the assessor that the operation was of no possible danger to the forest, one of them insisting that the Limnerium was a species of fruit and that it grew on the foliage and that they themselves would gladly undertake the collection of the cocoons, or rather the payment for them, for the 10 per cent commission offered. But there was a *fiesta* on, and any chance of getting anything further done that day was out of the question. Fiske wanted the boys to go back and take some more boys with them, but they deserted him before they got half way back to town. The combination of a *lira* apiece and a *fiesta* on the self-same day was one which might never come again in a lifetime and they proposed to make the most of it.

The next morning at seven the forest guards returned and Fiske explained the full details of the scheme, offered to advance three hundred *lire* (about sixty dollars) and thereafter pay for every shipment as they were received at Portici. He set the limit of expenditure at fifteen hundred *lire* and the time at two weeks. The offer was accepted, and he hurried to Messina and cashed a check, returning the same night to sign the agreement. During the day the guards had

succeeded in getting eleven boys who had brought in 2,290 cocoons which were paid for on the spot. The next day the promise was that thirty boys should be sent out.

Fiske then returned to Naples, and the cocoons began to come from Gioia Tauro. Naples at this time was practically quarantined on account of the cholera. On the 6th of July a large lot had accumulated, and a boat of the Lloyd Sabaudo Company was to sail that day for New York. The company officials said that they would not take the parasites. Fiske called on the United States Consul, who told him he would do well to see the medical officer and get a certificate from him to the effect that he was willing to pass the packages and that there would be no trouble on their account in New York. The medical officer was out to luncheon, so he got the packages down from cold storage where they had been placed on receipt from Gioia Tauro, and then back to the Consul's, but there was no medical officer and he was told that it would be impossible to see him that afternoon because he was attending a conference. But the Consul wrote out a formal letter on fine stationery, and armed with this Fiske went back to the steamship authorities. They were impressed by the seal and the embossed heading, and while they were considering it the captain of the vessel came in and absolutely refused to allow the parasites to go in his refrigerator. He said that if Fiske would let them go in the hold of the vessel he might consider it perhaps, but not in the refrigerator.

Undaunted, Fiske started for the American Express Company office, calling en route at the International Sleeping Car Company's office, where he found that if he could start the sending on the 6.50 train that evening it might possibly go through by express train without missing any of the series of close connections, in time to be shipped on the French Line boat *La Lorraine* from Havre the following Saturday at 7 p. m., arriving in New York on the 15th or the day after it would have to leave Naples on the next possible boat that sailed.

But he had almost no money and it was 4 o'clock in the afternoon. Nevertheless, he went to the American Express Company offices and proposed that some one should undertake to see it through, charges to be collected from the State of Massachusetts or from the United States Government. The Traffic Manager admitted that he would like the trip, and said that he was well acquainted with the French language and the idiosyncracies of the French customs officials. The only difficulty was to get the parasites into some shape so that they would look like baggage, whereupon the head of the shipping department led the way to the rear of the offices and pointed out a pile of old trunks that had been blockading the passage for a long time. They were a motly lot, but when sorted over five were found that Fiske

thought would do. The bundles of parasites were unpacked and repacked in these five trunks, and, the superintendent of the office having approved, the traffic manager started with his five trunks and an additional hamper on the 6.50 train for Paris.

The rest of the story is that he made the journey without accident, got the trunks on the *La Lorraine*, where they were put into the refrigerating room. They arrived in New York on time, were met by the Government Despatch Agent, Mr. I. P. Roosa, hurried through the customs, and shipped to Melrose Highlands, where they arrived in admirable condition, and when Mr. Burgess unpacked them he found that practically all were sound.

No further comments on this incident are necessary.

NOTES ON THE LIFE HISTORY AND ECOLOGY OF TIPHIA INORNATA SAY

By George N. Wolcott, *Traveling Entomologist, Porto Rico Board of Agriculture*

The most important parasite, in the United States, of the grubs of the genus *Lachnosterna*, commonly known as "white grubs," is a black Scoliid wasp, *Tiphia inornata* Say. The work on which I have been engaged for the last year, September, 1912, to November, 1913, is the collection of sufficient numbers of the cocoons of *Tiphia inornata* to send to Porto Rico, in order that the species may be established there to aid in the control of the Porto Rican *Lachnosterna* grubs, which are a serious pest of sugar cane and other crops. For the successful collection of large numbers of *Tiphia* cocoons it was necessary to determine what factors limited the abundance of *Tiphia*, to the end that fields and localities might be found where these factors would be negligible, or nearly so, and cocoons would be present in abundance. The great majority of cocoons that have been collected are from localities not far from Urbana (my temporary headquarters) and Bloomington in central Illinois. All the observations here recorded, upon which are based the conclusions that are set forth in the following discussion, were made in central and northern Illinois, and are strictly applicable only to that region.

No attempt has been made to do any taxonomic work on *Tiphia*, for all the adults which emerge in Porto Rico from the cocoons sent from Illinois, after being used in breeding, are forwarded to Mr. S. A. Rohwer, for study and identification. The results of this work are not yet available. The life history notes are incomplete owing to the fact that the cocoons are sent to Porto Rico soon after collection, but observations to supplement the data here given may be expected

from the workers in Porto Rico — Mr. Thomas H. Jones and Mr. E. G. Smyth.

The literature dealing with other than the taxonomic features of *Tiphia inornata* is very meager. Dr. C. V. Riley in his Sixth Missouri Report (pp. 123–126) is the first to record anything of its parasitic habits, life history, abundance and parasitism by *Rhipiphorus pectinatus* Fabr. He also quotes the original description of the adult by Say and adds other descriptive notes, besides figuring the adult, larva and cocoon. Prof. S. A. Forbes in the Twenty-fourth Illinois Report (pp. 157–160) gives much interesting and definite information regarding the life history and habits, and the colored figure (Plate x) of the larva, cocoon and adult is very good. Mr. J. J. Davis in Farmers' Bul. 543 on "Common White Grubs" (pp. 15–16) figures the cocoon and gives some descriptive and life history notes. My attempt in this paper is to add to the life history data and descriptive notes given by others, but the discussion on the ecological factors is entirely original and has not been touched upon by previous writers.

Life History

The adult *Tiphia* is entirely black with many grayish hairs on the head, thorax and abdomen, and is easily distinguished from all other wasps by the color and the constriction between the first and second abdominal segments. The males are smaller and more slender than the females.

The female *Tiphia* is quite often observed on cement walks and on the ground, and indeed she spends the major portion of her time in or on the ground. She has a quick nervous walk, and her movements give one the impression that her eager search is without definite plan. Seldom is flight attempted, although the wings are used to help in short jumps or quick changes of direction. Earthworm holes and all sorts of cracks and holes are explored and often the wasp disappears in a hole in the earth that proves attractive. The females have slight difficulty in working their way through black heavy clay soil in good tilth and seem to be successful in finding grubs even in a field where they are not abundant. The grub is stung by the female wasp until it ceases to resist her attempts to deposit an egg on it, but the effect of the sting is only temporary. Indeed, the grub is often so active in burrowing through the soil that the egg, or even the young maggot, may be rubbed off. Grubs are often found with a brownish lesion showing the point of attachment of a maggot that has been rubbed off. The egg may be deposited on either the dorsal or ventral surface of the thorax of a one-third to fully grown grub. In one instance where the egg was deposited on the dorsal surface of the abdomen,

the maggot died while still very small. The ventral surface of the thorax appears to be a safer and more protected position for the deposition of the egg.

Incubation of the egg and the growth of the maggot while small takes several weeks, but the growth of the maggot from one-third to fully grown takes only two or three days. The grub seems not at all discommoded by the presence of the parasitic maggot while it is small, but when the maggot becomes about one third grown, the grub is less active, its movements being confined to a restricted area. Its feeble movements in the earth appear to have the effect of preparing a cell which is well adapted for the spinning of the cocoon of the parasitic larva. In practically all cases, all of the softer portions of the grub are absorbed by the parasite, and only the heavily chitinized head and legs and the shriveled skin of the grub are left.

In the earthen cell, which is practically empty after the destruction of the grub, the *Tiphia* larva spins its cocoon. This is an elongate pear-shaped affair, or it may be described more exactly as shaped like an Indian club or a summer squash with the neck eliminated. Indeed, comparison of its shape to that of a squash is more nearly correct, as the pointed tapering end is noticeably bent to one side. The cocoon is composed of downy silk of uniform texture, somewhat the color of khaki cloth. Often the color is darker or redder, but the variation is trifling. The silk of the smaller species of *Tiphia* is light yellow or flaxen in color. The color bleaches quickly in bright sunlight, and cocoons found in fields that have been plowed only one or two days previous show the side exposed to the sun faded to a light gray. The cocoon is loosely suspended in the cell by scattered strands of silk, but from the pointed end it is more firmly supported horizontally by a little button of silk in the outer layer of the cocoon. This little button is firmly attached to the side wall of the cell. Although the cocoon appears soft and downy, it is really quite firm underneath the loose outer network of silk, and the inner cocoon, while composed of silk of the same color, is very tightly woven. Entangled in the loose outer threads of the cocoon, the mandibles, skull (head case) and shriveled skin of the grub are usually to be found.

It has been supposed that the eggs are often deposited on grubs too small to furnish sufficient nourishment for the parasite maggot to become fully grown and in such cases small cocoons are formed. It is almost certain, however, that these smaller, flaxen colored cocoons are produced by another smaller species of *Tiphia*, which attacks only small grubs, as these small flabby cocoons are often found in fields where large grubs are abundant. The males of *Tiphia* are considerably smaller than the females and the cocoons from which they emerge are usually smaller than those of the females.

In the late fall a considerable period may elapse after the spinning of the cocoon before transformation to pupa takes place, in fact, pupation may not occur till spring. But if the cocoon is formed early in the fall transformation to adult may be immediate. Indeed, it appears that *Tiphia* may hibernate either as larva, pupa or adult inside the cocoon. During the summer, however, the cocoon is occupied only a short time between the spring and fall generations. The shed pupal skin contains a considerable amount of a dense white fluid, which later dries in a solid mass. If the adult is active in the cocoon, the pupal skin is ruptured and the dried white mass is ground to a powder which is often seen dusted over the adult *Tiphia* when newly emerged. Sometimes the adult is active before the fluid dries and it presents a sorry spectacle, when the cocoon is cut open, as it crawls out covered with large chunks of the dried fluid adhering. Probably with normal emergence the adult is seldom covered with this powder, for many cocoons are found from which the adults have emerged and the pupal skin remains undisturbed and unbroken in the pointed end of the cocoon.

All my observations indicate that invariably the adults emerge through a hole cut in the side of the cocoon towards the surface of the ground. Usually this is also the larger end of the cocoon, where the head is located, but cocoons have been found with the exit hole cut half way, or more, down the side. This condition is not usual, and occurs only in cocoons exposed by the plow. Plowing a field has a most decided effect on the emergence of the adults from the exposed cocoons. Adults which would otherwise hibernate in the cocoon, often emerge late in the fall. Spring plowing may produce an earlier emergence because of the unnatural warmth caused by a few days' exposure to the direct rays of the sun. In 1913, normal emergence was general at Bloomington, Ill., on May 14. Indeed, after this date very few cocoons could be found from which the adults had not emerged. As grubs parasitized with very small maggots are found as late as the middle of September, the evidence seems to indicate two generations during the year. Plowing is not usual during the summer and it is difficult to tell what the normal subterranean habits of *Tiphia* are. The adults which prematurely emerge from their cocoons late in the fall appear to perish without ovipositing, as parasitized grubs are never found as late as October 1 as far north as Bloomington and Urbana, Ill. Early fall plowing, and indeed fall plowing in general, must be very unfavorable to *Tiphia*. Even those cocoons which are deep in the ground and are not disturbed by the plow will be somewhat affected, but the majority of cocoons are formed less than six inches from the surface, or in that part of the soil which the grubs normally inhabit during the summer months, and these are exposed to the

weather and to the attacks of birds and predaceous mammals and insects.

Ecology.

The various species of *Lachnosterna* in the Middle West are attacked by a considerable number of parasites and predators, but undoubtedly *Tiphia inornata* is the most important. I am convinced that under favorable circumstances *Tiphia* does greatly reduce the numbers of grubs and in some cases practically exterminates *Lachnosterna* from limited areas. The evidence is this: In some fields (near Randolph, Hendrix, White Heath, Ill., and at many other places) one will find many cocoons from which adults have emerged, a few in which adults are contained, and a very few grubs or beetles. Or in fields in which practical extinction of the grubs has taken place a year or more ago (near Weldon, Minooka, Seymour, Homer, Ill., and at other places) one can find only old rotten cocoons from which adults have emerged several months or a year previously, and few or no grubs and beetles.

The adult females of *Tiphia* are not strong fliers and they tend to remain in the field where their immature stages have been passed. When the grubs are abundant, no difficulty is experienced by the female *Tiphia* in finding sufficient numbers for the deposition of a large number of eggs. The rate of multiplication is rapid, for two generations of *Tiphia* probably occur during the summer. The supply of non-parasitized grubs in a field soon tends to become exhausted, necessitating a more careful search by the female to find a host for her eggs. The female, loath to search at great distances, eventually parasitizes practically all the grubs of suitable size in a field, until the dispersion of the females to new localities is necessary unless large numbers are to perish without depositing eggs. The males can fly long distances and are often collected feeding on the flowers of goldenrod and asters, but the females are less often found in these situations and apparently have difficulty in flying any great distance.

There are, however, several checks to an unusually great increase of *Tiphia* in restricted localities. Under favorable conditions, a fungus (probably *Isaria* sp.) causes a heavy mortality. Cocoons are often found covered with a weft of white mycelium densely covered with spores, spreading out into the surrounding earth. It has not yet been determined how infection by the fungus takes place—whether the spores only attack the parasite egg or maggot, or whether the mycelium is able to penetrate the cocoon. It may be that the fungus attacks *Tiphia* only when it is weakened by unfavorable conditions, such as sudden changes in temperature or too much or too little moisture, and is not pathogenic on healthy individuals. Naturally when *Tiphia* is most abundant the fungus will have the least difficulty in spreading and often nearly all the *Tiphia* in a field are killed in this way.

In addition to the fungus, *Tiphia* is attacked by at least two parasites—a bee-fly, *Exoprosopa fascipennis* Say (Bombyliidæ) and a beetle (Rhipiphoridæ). Riley identified the beetle emerging from cocoons collected in Missouri as *Rhipiphorus pectinatus* Fabr., but determinations have not yet been made of the beetles which emerged from cocoons collected in Illinois. The details of the life histories of neither of these parasites have ever been worked out. They seldom infest more than 1 or 2 per cent of the *Tiphia* cocoons. In one field, however (near Randolph, Ill.), a large number of the older cocoons in the field, instead of having a side emergence hole, showed the entire blunt end of the cocoon cut off. This was evidence of heavy parasitism by the Rhipiphorid, as *Exoprosopa* leaves its pupal case in a hole in the side much similar to that cut by the *Tiphia* adult. Cocoons showing no emergence hole are often found in the field pierced with a considerable number of small holes less than 1 mm. in diameter. The interior of such cocoons is entirely empty. What causes this is not known, although it may result from the grass roots which are often found wrapped round cocoons, or possibly the mites which often infest the grubs attack the cocoon when their normal host is destroyed by *Tiphia*. It has been suggested that ants might also cause this type of injury.

Although the parasites and the fungus are important in controlling the numbers of *Tiphia*, the most important check to the natural increase of the species is the lack of host grubs. *Lachnosterna* grubs are not present in noticeable abundance in the great majority of fields in central Illinois. Frequent plowing, rotation of crops, heavy pasturing of meadows and fields to horses, cattle and especially to hogs, which root in the soil after the grubs and destroy large numbers of them, and the absence of nearby trees to furnish a food supply to the adult beetles, may be mentioned as the more important checks on *Lachnosterna*.

The last mentioned factor seems to be of greater importance than is generally realized. The grubs of the species of *Lachnosterna* of which the adults prefer to feed on the leaves of willow and cottonwood (*Populus deltoides* Marshall) are almost invariably found abundant in those fields in which there are several large cottonwood trees. In the more hilly portions of Illinois, where fewer trees have been cut down, or even in fields near orchards or woods of oak, elm, ash, birch, linden, locust and walnut, *Lachnosterna* grubs are sufficiently abundant to cause serious loss to the farmers. Hedge (Osage orange), box elder and maple are the only three common trees that are not acceptable food plants to any *Lachnosterna* beetles, while cottonwood and willow are preferred by most of the common species. Oak and elm are a good third and fourth, but other trees are of minor importance. Despite the state-

ments in literature regarding the dispersion of the adults by flight to parts of the field distant from the food trees, the long flights observed are probably made by the males, for almost invariably grubs are most abundant near the food supply of the adults. In fields half a mile, or even quarter of a mile long, grubs will be abundant in the end near trees, and practically absent at the other end if no trees are near. Of course, grubs are not always abundant near trees, even when all other conditions seem favorable, and occasionally solitary grubs are found in fields a mile or more from the nearest food tree, and sometimes these grubs are parasitized, but these are exceptions. The comparative absence of trees throughout large areas of the more fertile and more valuable portions of Illinois, probably is the most important factor in limiting the abundance of *Lachnosterna*. If an abundance of grubs were to be found in most fields, the dispersion of *Tiphia* females would be greatly facilitated from a field in which most of the grubs have been parasitized, but as the supply of grubs is usually localized to a small area near a woods or clump of trees, the *Tiphia* remain in this locality, destroying all the grubs, and are themselves destroyed by the fungus which can more easily cause an epidemic among its crowded hosts, or else they perish without ovipositing while traveling to distant fields in search for grubs.

Practically all the fields from which the largest numbers of *Tiphia* cocoons have been collected were of these two types, either with several large cottonwood trees in the field or in a nearby hedgerow (near Champaign, Randolph, Wapella, Minooka, Hendrix, Ill.) or near oak or mixed woods (near White Heath and Monticello, Ill.). From only four other fields have collections of any size been made and these were of minor importance (near Rantoul south, Rantoul north, Monticello, Cerro Gordo, Ill.). Even in these cases, cottonwoods, willows, oaks or elms were not more than quarter of a mile away, and in at least two instances the fields had been unpastured meadows for several years prior to being plowed. In the great majority of all the fields, the plowing was for corn (5 to 7 inch deep) on land that had been in sod (clover, red and alsike, or grass) for two or more years and had not been pastured. The deep plowing made collection of cocoons possible and the other factors were of importance in producing an abundance of grubs—a potential host supply for a subsequent abundance of *Tiphia*.

In the more hilly and wooded sections of Illinois, the soil is not the typical black clay and brown silt loam of central Illinois, but is a gray clay of poorer texture, or a sandy, gravelly loam. To both of these types of soil another parasite of *Lachnosterna*, *Elis sexcincta* Fabr., seems to be better adapted, for in collections made near Galesburg,

Peoria, Allentown, Henry, Putnam, Sheridan, Rockford, Freeport, Winnebago and Belvidere, *Elis* is much more abundant and *Tiphia* is found in smaller numbers. Conversely, *Elis* is found in small numbers on the black clay and brown silt loam to which *Tiphia* is better adapted.

Still another factor which is of great importance in restricting the range of *Tiphia* is that only a single generation of the dominant species of *Lachnosterna* is present in some localities. For most species of *Lachnosterna* three years are required for the completion of the life cycle. The year that full grown grubs are abundant there would be an ample supply of hosts for *Tiphia*, but the next year only beetles, eggs and very small grubs would be present. Just this condition occurs in northwestern Illinois and every third year the farmers suffer great losses from the grubs. Probably the condition existing in this region some time ago was that parasites, such as *Tiphia* and *Elis*, were present, feeding in the years when the dominant species occurs as beetles or very small grubs, on the full grown grubs of some other species of *Lachnosterna*. In the year when the grubs of the dominant species were abundant, the numbers of *Tiphia* increased greatly. The next year the grubs of the non-dominant species would be only a meager supply to the large numbers of *Tiphia* and practically all the grubs would be parasitized. This would eliminate the non-dominant species, and in the coming years *Tiphia* would have no host in the years when the dominant species did not occur as large grubs, and it also would be exterminated. The elimination of the non-dominant species may also have been caused by the cutting down of trees that formed the food supply of their adults. Whatever caused the elimination of the non-dominant species, until conditions are again favorable for their increase no possible assistance can be expected from *Tiphia* in the destruction of the dominant species.

There appear to be at least five important factors controlling the abundance of *Tiphia inornata:* (1) Scarcity of large grubs in the years when the dominant species occurs as beetles and small grubs. (2) A permanent scarcity of grubs caused by unfavorable agricultural practices, or the absence of trees to furnish a food supply for the adults. (3) Unfavorable soil—which favors other parasites of *Lachnosterna*. (4) Parasites on *Tiphia* and the *Tiphia* fungus, *Isaria sp.* (5) Fall plowing—which causes premature emergence of adults and exposure of cocoons to predators.

FURTHER NOTES ON THE BREEDING OF THE TACHINID FLY, PARASITIC ON THE CANE BEETLE BORER[1]

By J. F. Illingworth, Ph.D., *Professor of Entomology, College of Hawaii, Honolulu, T. H.*

On April 21, 1913, I signed an agreement with Dr. Harold L. Lyon, who was acting as agent for the Colonial Sugar Refining Company, to undertake to transport from Hawaii and establish in the cane fields of Fiji, the Tachinid fly (*Ceromasia sphenophori*) which is parasitic on the cane beetle borer ([*Sphenophorus*] *Rhabdocnemis obscurus*).

I had just a month before my boat was to sail in which to make all preliminary arrangements, so I at once began a search of the various plantations on the Island of Oahu that I might collect as large a number of the parasites as possible. It was decided to carry the majority of the parasites in the form of maggots within the borer grubs since the adult flies are very difficult to keep alive in confinement. Previous investigation had shown that the parasitized grubs must be kept separate or they will quickly destroy each other. The most practical method, already developed, was the separation of the grubs into individual vials. Although the grubs when thus separated will live for several weeks without food, I decided to keep them well supplied, by placing bits of fresh cane in the vials from time to time as fast as they ate it. In this way I hoped to favor the development of the parasites. When the grubs were left in empty vials for some time, they were found to gradually decrease in size, and the resulting parasites were poorly developed.

During the collection of parasitized grubs many puparia of the flies were found inside the borer cocoons; these were all saved, hoping, that part of them at least would not emerge until I reached Fiji. However, some of the flies emerged from these daily, but a few lasted through.

It was with much difficulty that I found a locality in the vicinity of Honolulu that would furnish sufficient parasites for my needs. The evidences of the flies were everywhere, but they had done their work and gone. Empty puparia were found in most of the borer cocoons. Even in a small field of the Honolulu Plantation, which had been abandoned because of the abundance of borers, I found few grubs. Almost every stalk had been infested, but the empty puparia were all that remained to show that the flies had been there and done their work.

By much traveling from one end of the Island to the other I was able to collect, with assistants, about 1,000 of the borer grubs. I had to take a chance that most of them would be parasitized, since

[1] Contribution from The College of Hawaii.

they were all collected in fields where the flies were abundant. I estimated that if I could get these 1,000 grubs safely to Fiji, enough flies would emerge to fully stock several cages, and have a fair colony to liberate in the field at once.

During the voyage about 100 of the flies emerged from the puparia which had been found in the borer cocoons. It is rather interesting to note that the emergence of the flies invariably took place in the morning. If the weather was warm, the first flies appeared about daylight, and they continued to emerge for about three hours; on cool mornings, the emergence sometimes did not begin before 10 o'clock.

All of the flies that emerged during the trip to Suva were put into inverted glasses, on sheets of clean white paper. They were daily supplied with fresh slices of cane and bits of cotton batting saturated in water. By giving them moisture in this manner I avoided the difficulty of having them injure themselves by getting wet, as they invariably do when in close confinement. Even a drop of water on the paper soon resulted in several being upset and stuck in it.

By using greater care than one would need to give to a lot of babies, I was able to save practically all the flies that emerged en route.

On reaching Suva, the flies that were already emerged were quickly taken to the nearest of the plantations—twelve miles away, at Nausori, on the Rewa River—where cages were already prepared. Half of the flies were placed in one of the cages, which had been stocked with canes containing borer grubs; the other half were placed directly in one of the badly infested fields. This part of the island has a heavy annual rainfall and the cane is ripened with some difficulty. Since the failure of three previous attempts to introduce these Tachinid parasites at Nausori was attributed to the excessive humidity, we decided to take the greater part of our parasites to a drier section. We found Nadi district, which is situated about 100 miles from Suva, at the far end of the island, most perfectly suited to our needs. Two cages (Plate 10, Fig. 1.) were at once completed and stocked with grub-infested cane, about 50 flies were placed in each cage.

The remainder of the parasites which were, by this time, in the form of puparia, we decided to at once place in the field to emerge. The jars containing the puparia and damp frass were placed in a shelter and protected from ants, in a way similar to that used in Hawaii. We were unprepared, however, for the disaster that awaited us when we visited the field on the following morning—the rats (or mice) had gotten into the box and clawed out all the frass and puparia from the jars, destroying most of the flies. This left us with only our cages to fall back upon, but we had had the experience,—the liberating boxes must have mouse-proof screens.

Mating Observations

With all the study of the flies that we had done in Hawaii, their copulation had not been observed. In most instances, in the study of any economic species, a knowledge of the mating habits is very important. This is especially true in the present case, since we then knew when the flies were ready to reproduce. We first saw the flies mating when they were six days old, but later observation on the second brood showed that they begin mating on the same day that they emerge, in fact, when they are only about six or eight hours old.

A detailed account of these observations may be of value here. The male during copulation, stands on top of the female, his fore feet on either her head or thorax; the middle feet on the outspread wings; and the back clasping her abdomen. The mating, during the first day, was for very short periods, not more than half a minute at a time. It resembled very closely that of the ordinary house-fly. However, during the second day, they remain together for about four minutes, and, on the third day the average time required for copulation was a little over 18 minutes. Mating, evidently, is continued from time to time for a considerable period, since it was observed in the first instance on the sixth day.

Larva-positing

Mr. Frederick Muir, of the Hawaii Sugar Planters' Association, by careful dissection, estimated the number of eggs which the flies were able to produce. In one case he found 570 fully developed eggs in the uterus, and many others filling the fallopian tubes and ovaries. Thus the number of young possible for a fly to produce is upwards of 1,000. Mr. Muir also discovered that the eggs hatch while still in the uterus of the fly, and are deposited as living maggots. This is particularly favorable to their multiplication, since the little, active maggot at once enters the grub, and escapes the myriads of ants that swarm over the canes.

While these flies are rather quiet they appear to be very reticent about letting one see them larva-posit. After continued observations I was able to see this interesting process several times. The female was first noticed carefully examining one of the minute pin-holes, made by the borer grub through the rind of the cane. Her head was held very low, with the antennæ close against the surface of the cane. It is well-known that the organs of smell in insects are located in the antennæ; so she was evidently smelling to decide whether a borer grub was near the opening. In about two seconds she touched the tip of her abdomen to the surface of the cane, twice, and deposited two active maggots. They were side by side, about 1 mm. from the pin-hole, and

Breeding cages at Nadi, Fiji. Nets over doors were for catching flies that escaped when cages were entered

Liberating boxes in the field at Nadi, Fiji

in moving about, quickly reached the opening and disappeared. The fly paid no attention to the larvæ after depositing them on the cane. In a number of other observations the flies were proved to have first located the borer grub, positively, near the pin-hole before depositing the maggot. This was done, in several instances, by cutting into the cane and finding it just inside the spot.

In one case a grub was removed in half an hour after the larvæ entered the pin-hole, and they were later found to be inside of him. Hence, they lose no time in boring their way into the living grub.

Continued Supply of Cane and Grubs

Another discovery that proved of great value to the breeding work was made while rearing the first brood of flies. A fresh quantity of cane containing borers was added to one of the cages, when the flies were 16 days old. Evidently they had pretty well gone over most of the borers already in the cage; at any rate, as soon as the fresh borers were introduced, they left the old canes and all congregated about the new ones. One might conclude that they were after the fresh supply of sugar, but this did not appear to be the case, for they became very active in their search for the pin-holes of the borers. This discovery indicated plainly that the flies must have a continued supply of fresh grubs if they are to give their maximum returns in breeding work. Our later results, when this was carried out, proved most gratifying.

Observations of the second brood gave us further information as to the time that must elapse after the flies emerge before larva-positing begins. In the case of the flies that copulated during the first day, they were seen intently examining the pin-holes of the borer when only two days old, and one was seen larva-positing on the third day.

Some of the flies in our cages remained alive and actively larva-positing through the entire period of six weeks, which is the ordinary time required for a generation to develop.

Light Relation

Most insects show a decided attraction to light, only a few seeking dark places. These Tachinid flies from their habit of living in the cane field, we would conclude, should have all degrees of light and shade.

In experiments in Honolulu it was soon learned that they were not contented in cages that were too dark, and refused to larva-posit. The same thing was partially true when the cages were provided with no shade. In our experiments on this point, in Fiji, we tried to supply as nearly field conditions as possible. In the cage that was so arranged we got our best results. This cage had a few leafy stalks of

cane through the center and at each side. Small, broad-leafed weeds from the cane fields were planted here and there around the edges. The flies seemed particularly fond of these plants, resting on the leaves in the sun, or going under them when it rained. The walls of the cage were made of good quality cheese cloth, and the top of mosquito net. The cloth on the sides shut out most of the strong wind on bad days, and the top net gave the flies a chance to get into extreme sunlight early in the morning or on cool days.

It was seen that the flies invariably sought the sunlight on the cane leaves or net early in the morning, and as the heat increased they gradually went further and further into the shade on the stalks, some even going to the moist shaded soil when the sun was too hot.

The flies are particularly active as the sun begins to warm up the cage, buzzing about near the top or anywhere they can get into direct sunlight. This is the time that they do their mating, hence it is very important that no obstruction shuts off the morning sun.

We found that a few cocoanut leaves tacked on the outside of the cage, gave an effect of light and shade that was very satisfactory before we got the cane growing inside. One has to use his judgment in this matter, however, and not everdo it. There must be at least as much surface where the sun can enter as is covered by the leaves. Later, as the green leaves developed inside, the cocoanut leaves were gradually removed, only two or three being retained on the top of the cage as a protection from the noonday sun.

Moisture

Flies in general require an almost continual water supply. They, like ourselves, can do for long periods without food, but quickly succumb to drought. Hence the matter of supplying moisture required careful regulation. After a good growth of cane was developed in the cages the problem was much simplified, for small drops of water are usually given off by the leaves in transpiration. During dry or windy days it was often necessary to spray the leaves several times. For this purpose an ordinary brass garden syringe with very fine holes was used. The soil, too, was kept well moistened so that the plants would thrive. In rainy weather the surplus water was provided for by boring drainage holes through the floor, and covering them with screens. Small pools of water in the cage are always a source of danger, for the flies sooner or later get into them and are destroyed.

Liberation of Flies in the Field

During the development of the flies in the cages a careful survey had been made of the various estates in the Nadi district, preparatory

to the liberations of the flies in the field. A field of ratoons was located, which was well advanced and badly infested with borers. Furthermore, the field was not to be cut for four or five months, in which case the flies would have opportunity to multiply greatly, and spread to adjoining fields of young cane which were already being infested by the beetles.

After six weeks, the parasitized canes were removed from the cages and placed in the field in upright boxes (Plate 10, Fig. 2). In order to protect these from ants, legs were attached and they were placed in tins of water. Exposure of the bare cane to the direct rays of the sun, at noonday, would quickly kill the enclosed parasites, so we finally developed a method of tacking cocoanut leaves to the boxes, which proved very satisfactory.

A few of the canes were opened up to form an estimate of the number of parasites:—87 borer cocoons opened, showed 75 that were parasitized—containing 172 fly puparia. This gave a result of 86 per cent parasitized.

During the second generation of the flies we put many more grubs into the cages than in our first experiment. Then, by putting in fresh cane and grubs daily, during the whole six weeks, we were able to more than treble the results of the first generation. From a total of 4,354 borer grubs that were put into the two cages, a careful estimate made by opening some of the canes as above, showed that we had fully 5,000 parasites developed. These were liberated in several fields of the Nadi district, about 1,000 or more being put together in each place.

Continuous Breeding

Since some of the flies of the second generation lived right through the period of six weeks, it was decided to date the canes as they were put into the cages each day, and remove them for the purpose of establishing colonies in the field at the end of about five weeks. By this method of adding new artificially-infested canes daily, and keeping always about 60 flies in each cage, we were able to remove 55 or 60 canes, containing fully 600 parasites, once a week. These parasitized canes were shipped to various parts of Fiji, wherever borer-infested fields were located. They were all exposed in upright boxes as shown above.

Enemies of the Tachinid Flies in the Field

It seems wonderful that the flies are able to reproduce at all in the fields when we see all of the organisms that prey upon them. It is only by their abundant powers of multiplication that they can overcome these natural enemies; the principal difficulty is in getting a

strong enough colony established that they may continue in spite of the loss. A brief discussion of these enemies may not be out of place here.

Before the flies escape from the cocoon of the beetle, many of them will be destroyed by rats. These rodents are particularly abundant in some fields and especially so under the moist climate conditions about Nausori. There I found many of the borer cocoons had been torn open by the rats in their search after the borer grubs. This loss will not be of any importance, however, after the flies become once established.

I should place the small brown ant (*Pheidole megacephala*) at the head of the list of mortal enemies of the flies. This is one case where his great industry will not be appreciated. At every stage of our breeding work we had to contend with these insects. They were on the ground about the cages in myriads; at the least opportunity they swarmed inside, if a mere thread was blown on to the protective water basins, we found that they had moved in their whole household by morning. We used carbon-bisulphide most effectively in such cases. We often noticed the adult flies attacked in the field soon after they emerged. Even a single ant, when he sets his jaw like a bull dog upon the fly's leg, seems to render it helpless, at this time. Often upon the stalk where the flies are emerging, we find a swarm of ants.

It is only because the borers plug the channel behind them and build an ant-proof cocoon, that the maggots are saved from destruction. The ants, even make short work of the borer itself, if it fails to take these precautions. Many times we had the ants get into our vials and bite holes in the grubs, even carrying them off piecemeal. The puparium of the fly, is usually found inside the cocoon of the borer; but even when free, in the borer channel, the ants appear unable to injure them.

Everywhere in the cane we found spiders; a large jumping species being most common. We did not see them in the act of springing upon one of our flies, but they were observed feeding in this way upon some of the other species of flies which are common in the cane field. These spiders never build webs but hide away in the leaf-sheaths of the cane and spring upon any unsuspecting insect that chances to alight near them. The habit of the Tachinid flies of searching about over the cane stalks renders them an easy prey to such attack.

Lizards, too, were rather common in the cane. One species, with feet fitted for an arboreal life, gave us considerable trouble by getting into our cages. Each one captured, showed on dissection, that he had his stomach filled with insects; but we never happened to find any of the Tachinid flies. Undoubtedly, however, he would take them if they chanced in his way, for he usually had several species of flies in him.

Dragon flies were very abundant in the field, especially during the evening. We often observed them circling about our liberating boxes, feeding upon the smaller insects. Though their principal food consists of flies, we never observed them in the act of catching one of the Tachinids.

Insectivorous birds appeared to be even a greater danger. Two common species were observed with some care—a small fly catcher, and a swallow. The first, flies in and out among the canes, and no doubt does considerable good in checking the ravages of several cane pests. His habits, nevertheless, render him a foe to the fly. The swallows feed entirely on the wing, over the cane or in the open places. Their beaks could be heard continually clipping together, registering the number of insects that they were taking in their swift circling flight. Probably the flies would receive little injury from them, except during the mating flights of the Tachinids, when they buzz about over the cane. Definite data on this subject could only be secured by making an examination of the stomach contents of a number of the birds that were killed after they had been feeding for some time.

There are a number of other organisms that are closely associated with the developing flies in the field which may prove to be detrimental to them. The earwigs that are ever present in the leaf-sheaths of the cane, are known to be often predaceous upon other insects. Cockroaches, too, are to be found everywhere, and are omnivorous feeders. The tunnels of the borer were often filled with mites. These attacked the emerging beetles in great numbers and were often found on the newly emerged flies. Whether or not any of these do serious injury to the Tachinids, needs further investigation.

Since the first flies were liberated during the latter part of July, it is rather early at this writing—November 12th—to find the parasites in the field. Though the flies were found to be established in Hawaii in about three months after they were liberated, we do not expect to discover any of the parasites in the field, in Fiji, until the cane is cut in December. When the flies are actually found breeding outside, the troublesome work with the cages can be discontinued.

Bibliography

The published notes on the breeding of these flies are principally found in three papers in the *Hawaiian Planters' Record* by Mr. Frederick Muir, as indicated below. In these papers Mr. Muir describes the many experiences and hardships of his search for the parasites, throughout the East Indies; and the final successful landing, in Honolulu, of a good colony of adult flies and puparia; the results of which have proved so beneficial to the sugar industry here.

1909. Muir, F.—Report on the sugar cane borer in the Moluccas. The Hawaiian Planters' Record, Aug., p. 40–48, 1 map showing routes taken by Mr. Muir.
1909. Muir, F.—Concluding report on travels in the Malay Archipelago, in search of parasites for the cane borer. The Hawaiian Planters' Record, Nov., p. 256–261.
1910. Muir, F.—Report on second trip to British New Guinea to obtain a Tachinid fly, parasitic on the sugar cane beetle borer. The Hawaiian Planters' Record, Oct., p. 186–200, 5 figs. of fly.
1911. Villeneuve, Dr. J.—Description of *Ceromasia sphenophori*. Wiener Entomologische Zeitung, Vol. XXX, p. 81.

A NOTE ON RHAGOLETIS POMONELLA IN BLUEBERRIES[1]

By William C. Woods

In the spring of 1913 the attention of the Maine Agricultural Experiment Station was called to a certain maggot infesting the blueberries in Washington County; and, accordingly, at the suggestion of Dr. Edith M. Patch, the writer made a few observations on this insect during the summer. Although the work was merely of a preliminary character, the adult was reared, and it seems possible that a brief statement of the situation may be of interest. When bred, the maggot proved to be *Rhagoletis pomonella* Walsh. This appears to be the first record from the blueberry, although at least twice it has been reported as bred from the huckleberry, once by Doctor Britton in 1906 (Fifth Report State Entomologist of Connecticut, 1905, p. 260), and again in 1910 by Doctor Smith (Report New Jersey State Museum for 1909, p. 802).

Washington County, which includes a considerable territory in southeastern Maine, is the principal home of the blueberry industry in the state. Roughly speaking, there is a large area of about 250,000 acres in this county naturally unforested, known as the "barrens," which has grown up almost entirely with blueberries. Three of the species, *Vaccinium pennsylvanicum*, *V. canadense*, and *V. vacillans*, were to be found attacked by the maggot during 1913. The plains are privately owned, but during the berry season, for a moderate rental, pickers are granted the right to gather the berries, most of which are sold to one or another of the eleven canneries located in the state.

July 30, when the berries were just beginning to ripen, was the first date on which the plains were visited. No maggots were in evidence, but six adult Trypetids were caught hovering around the berries. These flies resembled the apple maggot exactly, except that

[1]Papers from the Maine Agricultural Experiment Station: Entomology No. 73.

they were smaller. Specimens were submitted to Mr. C. W. Johnson of Boston, who very kindly determined them as undoubtedly *Rhagoletis pomonella*. It is interesting to note in this connection that the flies reared from huckleberries in Connecticut were also below the normal size of the apple forms.

On August 19, when the plains were again visited, six more adults were taken. Larvæ were by this time common on the plains. When the maggots are small, an infested berry cannot be distinguished by sight from a sound one, but usually when they have attained a fair size the fruit becomes very much shrivelled and shrunken. At all times, even when the larvæ are small, an infested berry can easily be distinguished by the touch, for it feels soft and mushy, and this is the surest external indication that it has been attacked. In an infested berry, the pulp becomes red and stringy. Maggots were found at this time in all stages from very small ones to those fully grown. The maggot appears to become full fed in one berry, which it leaves by an irregularly shaped exit hole through the skin, in order to pupate in the ground.

The berries are picked by a rake somewhat similar to that used for cranberries, and usually are given a preliminary winnowing in the field to remove the leaves, etc. Many of the infested berries are also blown out in this process as they are much lighter than the others. While the maggots were common to abundant on the plains, it should be stated that the blueberries grew so profusely, oftentimes being so plentiful as literally to color the ground blue, that only a small proportion of the fruit was infested. The testimony of the pickers varied greatly, but the opinion of most seemed to be that the maggots became more and more numerous as the season advanced, and that a wet season was particularly favorable to their development.

A third trip on September 5 showed the maggots still present and common in all stages.

Berries were placed under breeding cages on cheese cloth spread over moist dirt, and the larvæ that had left the berries, as well as the pupæ, were removed from these cages as follows:

MATERIAL COLLECTED JULY 30

29 pupæ on August 22.

MATERIAL COLLECTED AUGUST 19

	Aug. 22	Aug. 23	Aug. 25	Aug. 27	Aug. 28	Aug. 30	Sept. 2	Sept. 4	Sept. 8
Pupæ	7	4	4	33	7	22	38	10	50
Larvæ	4	6	20	3	7	2	7	2	

MATERIAL COLLECTED SEPTEMBER 5

	Sept. 9	Sept. 13	Sept. 15	Sept. 22	Sept. 24	Sept. 26
Pupæ	20	16	12	15	18	4
Larvæ	9	14	26	5	1	4

On February 12, 1914, an adult male emerged in the laboratory which is the same species as those taken on the barrens last summer, thus establishing beyond a doubt the fact that at least in southeastern Maine the maggot which breeds commonly in the blueberries is *Rhagoletis pomonella*.

INJURY TO TRUCK CROPS BY SPRING-TAILS[1]

(*Smynthurus* sp.)

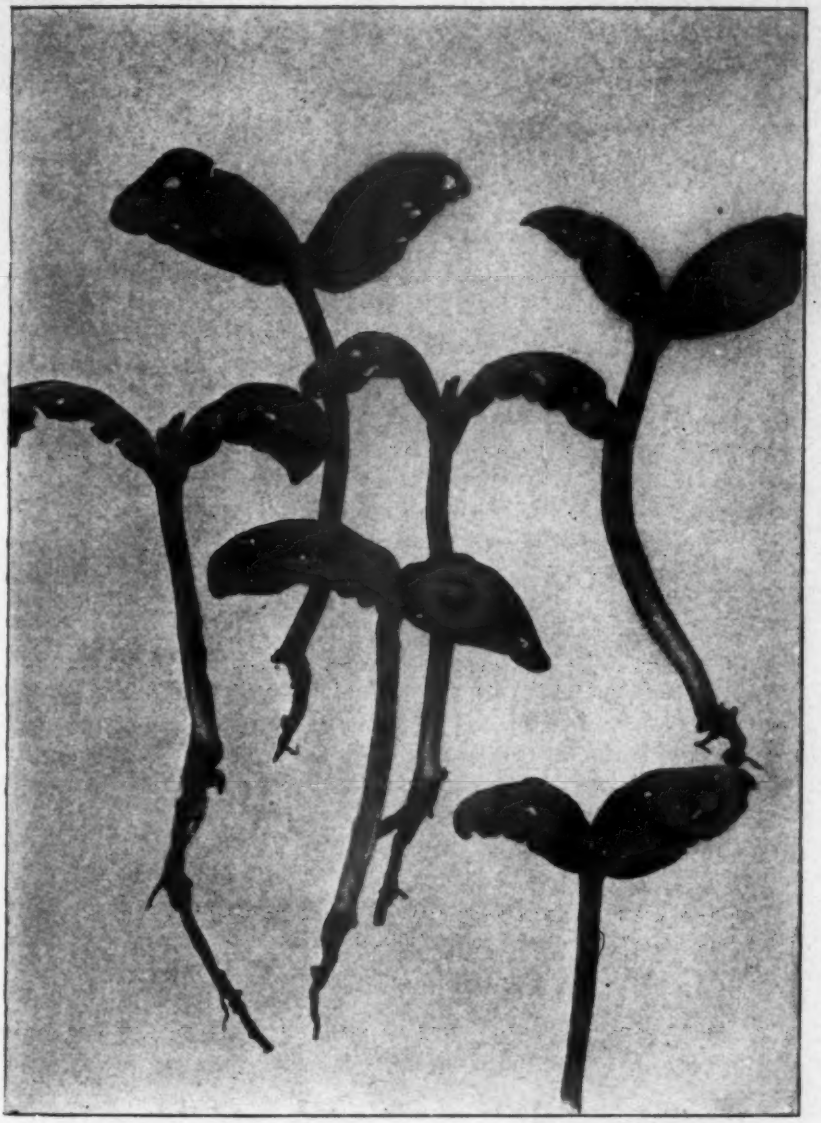
By D. E. Fink, *Entomological Assistant [Truck Crop and Stored Product Insect Investigations], Bureau of Entomology, U. S. Dept. Agr.*

Recent Injury

For the past year, 1913–14, instances of injury by spring-tails to lettuce, spinach, and seedling cucumber came under the observation of the writer in the vicinity of Norfolk, Virginia. During the spring of 1913 a seedling bed of lettuce was found injured by a species of spring-tail near Mason Creek, Va. Later, seedling cucumbers just above ground were severely infested, the injury being so severe that a replanting was necessary. During the fall of 1913 spinach was infested with spring-tails but no injury was evident. Very late in autumn, a large number of the spinach plants began to turn yellow from the center outward. At this time the spring-tails were found in small numbers at the base of the plants and not on the foliage. Whether the spring-tails are concerned in the injury to spinach which is in this vicinity known as "blight" is as yet mere conjecture. But the fact that during the late fall and winter the spring-tails confine their attacks on the spinach to the petioles of the leaves would cause the latter to turn yellow and later give the observer the impression that it is due to "blight," as the leaves show no form of injury by insects.

On April 30 and May 1, 1914, seedling cucumbers were again found severely infested by spring-tails. These little pests have increased enormously since the past year and the cotyledons of cucumbers have in many instances been completely devoured as they appeared above ground. On May 2, 1914, a field of potatoes in Kempsville, Va., bearing vines only two inches above ground was found severely infested with spring-tails. They were found feeding on both the upper and lower surfaces of the leaves, as well as on the margins where the Colorado potato beetle (*Leptinotarsa 10-lineata* Say.) had been feeding. As many as 40 to 60 spring-tails were counted on a leaf, and several hundred to a plant. Although the spring-tails are easily disturbed, the

[1]Published by permission of the Secretary of Agriculture.



Seedling cucumbers injured by spring-tails, *Smynthurus* sp. (Original)

mere approach to a plant is sufficient cause for them to disappear, yet at times one may approach sufficiently close to observe them feeding, and by vibrating a leaf with the rhythm of the wind one may even tear it off finally and examine it by the aid of a lens. The injury done by the spring-tails is in the form of irregular holes sometimes eaten completely through, though more often a thin transparent layer of epidermis separates the upper from the lower surfaces. They also enlarge the holes made by flea-beetles that happen to be feeding on the leaves.

The species has been determined as a Smynthurus but cannot be positively identified. It is positively not the same as *Sm. hortensis*. It is a thysanuran of the suborder Collembola.

Food Plants

At the present writing this species of spring-tail has been observed and reported as feeding on the following food plants: Lettuce, spinach, turnip, kale, potato, tomato, cauliflower, cucumber and peas.

It has also been observed on beans and strawberries, but whether it feeds on these plants has not been determined.

Feeding on Potato Beetle Eggs

While making observations on the extent of their injury to the foliage of potato, hordes of spring-tails were found congregated around the egg masses of the Colorado potato beetle, feeding on them with as apparent relish as on the foliage.

Control Measures

During the spring of 1913 arsenite of zinc applied at the rate of 2 pounds to 50 gallons of water to seedling cucumbers proved successful in its control. It was also noticed that while using arsenite of zinc as a spray for this species that the arsenical acted as a repellent, driving the spring-tails from cucumber to peas which were grown between the rows, a common practice in tide-water Virginia. Arsenate of lead used in the proportion of 3 to 4 pounds in 50 gallons should also prove effective.

CONTRIBUTIONS TO THE LIFE HISTORY OF THE LESSER PEACH BORER IN OHIO

By J. L. King

During the summer of 1913 observations were made on the life history and habits of the lesser peach borer, *Synanthedon pictipes* G. & R., in the lake district of northern Ohio. The most important fact established by these observations is that this species has one full brood

and a partial second brood in the Lake Erie District. In the vicinity of Washington, D. C., and the more southern states evidence of a second brood has been previously noted[1] by other observers.

In Ohio the first moths from the hibernating larvæ appeared May 15, 1913, and from then on the moths gradually increased in numbers, reaching a maximum in mid-June. Their numbers then declined appreciably until early August, though at no time did they entirely disappear. This dearth seems to be followed by another period of increase during August at the same time that *Sanninoidea* has reached its maximum brood period in that district.

There is little doubt that the first period of maximum occurrence in June marks the height of the first or spring generation. This was determined by enclosing the trunks of twenty trees in wire-cloth cages and by making daily counts of the emerging moths from May 1 to August 20.

Eggs obtained from the spring generation of moths hatched in seven to eight days and larvæ were successfully reared through to the adult stage. The larvæ of the second or summer generation grow rapidly. The minimum period of growth was, in the case of a male, from July 26 to September 7, a period of 44 days. In another case of a male, from June 20 to August 12, or 54 days. A female of the same brood completed her cycle in 55 days. Other periods of development were 71 days for two females and one male. The longest period noted was from June 20 to September 7, or 80 days. The growth period varies much in the individuals of the same brood, much depending upon the environment. Thus, larvæ twelve days old measured from 2.57 mm. to 5 mm. in length. The same brood, thirty days old, had length variations of 6, 10, 14 and 17 mm. respectively. When 41 days old, three of these larvæ measured 20 mm. in length, being fully grown.

The larval development is complete in six instars. The following is the history of a single larvæ through its entire period of growth.

Instar 1. Hatched July 26—First ecdysis July 29. Length, when full grown, 2.75 mm.

Instar 2. July 29—Second ecdysis August 2. Length 4 mm.

Instar 3. August 2—Third ecdysis August 5. Length 6.5 mm.

Instar 4. August 5—Fourth ecdysis August 9 at 10.00 a. m. Length 8.5 mm.

Instar 5. August 9—Fifth ecdysis August 13. Length 13 mm.

Instar 6. August 13—Sixth and final larval ecdysis August 26. August 26 to September 7 in cocoon and pupa; September 7, emerged as adult male. Life cycle completed in 44 days.

From the foregoing data it should be noted that all second brood larvæ emerged as adults during August and the first week in September,

[1]Part IV, Bull. 68, Bur. Ent. U. S. D. A.

which time practically corresponds to the second period of maximum occurrence during August. Thus it seems very probable that the apparent increase in August marks the height of the second or summer generation. The habits of this species make it quite difficult to determine the numbers and duration of the brood. It seems not impossible that if the life cycle can be completed in forty-four days that there might even be a small third generation, though no further facts supporting such a possibility have been noted.

AN UNRECORDED PARASITE OF TOXOPTERA GRAMINUM

By F. M. Webster, *Bureau of Entomology*

In the proceedings of the United States National Museum for 1888, page 641, the late Dr. Wm. H. Ashmead described *Wesmælia rileyi* "from six specimens in the Riley collection." No other information was given in connection with this description to indicate the locality from which the specimens came or the circumstances under which they were obtained. Doctor Ashmead, however, points out that "this remarkable insect agrees with the definition of this genus but seems out of place in the group and more closely allied with the group *Aphidiinæ*, where it may ultimately be placed."

In the proceedings of the Entomological Society of Washington, Vol. III, March, 1894, page 58, Doctor Ashmead erects a new genus, *Eupachylomma*, for this and another species which he himself discovered on Arlington Heights, on the Potomac River, in 1889. In this paper relative to *E. rileyi*, Doctor Ashmead states that "it was originally described from specimens in the collection of the national Museum, labeled No. 124, July 28, Collector, C. V. Riley, but no record of its habits or rearing could be found." In order to anticipate any further misconceptions, it may be stated that all of the specimens of this species, used in connection with the original description or in connection with this supplementary treatment of the species, were reared by myself at Oxford, Ind., July 25–28, 1884. These specimens appeared in a breeding cage to which growing wheat, from the fields, had been transplanted on the 12th of June previous. Shortly after this wheat had been transplanted the writer discovered *Toxoptera graminum* in the cage, as stated in bulletin No. 110, United States Department of Agriculture, Bureau of Entomology, page 15. On the 25th of June, a single individual of *Eupachylomma rileyi* appeared, followed by others. They were, with a single exception, submitted for determination August 19, 1884, as possible parasites of *Isosoma grande*, which was being reared in the same cage, the *Toxoptera* having

been accidentally introduced. In replying, Doctor Howard, then an assistant, now Chief of this Bureau, states that "Your number 124 is an *Aphidius* and was undoubtedly bred from *Toxoptera* and not from *Isosoma*." That the species is parasitic upon *Toxoptera* is further indicated by the fact that no other aphids were to be found in this cage, either at that time or later, and this parasite did not appear in other cages where *Toxoptera* was not present. Number 124 to which Doctor Ashmead refers in his paper in the *Proceedings* of the Entomological Society of Washington, is my old original number. While one specimen was sent to Doctor Ashmead in corresponding with him on June 1, 1893, from Wooster, Ohio, this was from the same rearing as the original specimens sent to the Department, August 15, 1884.

On account of the obscurity that has surrounded this species it was unfortunately overlooked and not included in Bulletin No. 110, by myself and Mr. W. J. Phillips, on the Spring Grain-Aphis or Green Bug, *Toxoptera graminum*. It is also interesting to observe that the species has not again appeared in any of our rearings of *Toxoptera*.

A NEW LEUCOPIS WITH YELLOW ANTENNÆ

By J. M. Aldrich *La Fayette, Ind.*

Specific characters in the genus Leucopis are so obscure and uncertain that one is almost inclined to doubt whether the half-dozen nominal species from North America are not really all forms of the same one. I am quite unable to distribute my forty-odd specimens into species, either by the table given by Thompson (Canad. Ent., XLII, 238, 1910), or that of Melander (Jour. N.Y. Ent. Soc., XXI, 232, 1913). Some material lately sent me from the Bureau of Entomology for identification proves to be very distinct in having yellow antennæ, those of the described species being black in ground color. As the group is economically important, the larvæ being predaceous upon aphids and coccids, it seems desirable to publish a description of the new form.

Leucopis flavicornis n. sp. Head, thorax, and abdomen except basal segment cinereous pollinose, almost plumbeous, with silky lustre; antennæ except basal joint, tibiæ and tarsi except tips, yellow; thorax and abdomen without brown stripes or dots; palpi black.

Third antennal joint large, orbicular, the thickened basal joint of the arista also yellow; mesonotum almost uniformly beset with rather coarse, erect black hairs, a very narrow median line, however, bare and hence appearing paler; scutellum and hind edge of mesonotum destitute of these hairs. First abdominal segment brown except hind edge; the numerous hairs of the abdomen (coarser and more scattered than those of the thorax) arise mostly from good-sized black dots, which are not sharply defined. Trochanters yellow, femora brown to blackish along the middle.

Length 2.2 mm.

Eight specimens, Brownsville, Texas; reared by R. A. Vickery from a colony of Pemphigus (probably *P. fraxinifolii*) taken from leaves of ash, May 10, 1910. Four specimens, including the type, are deposited in the United States National Museum.

The chætotaxy of the species is identical with that of others which I have examined, no specific differences appearing in any that I have noticed; it is as follows:

Head: post-vertical, ocellar, frontal and vibrissæ wanting; vertical two small pairs; one proclinate on middle of bucca.

Thorax: two pairs dorsocentral, far back, the anterior small; humeral 1; notopleural 2; presutural 1; sternopleural 1; intraalar 1 (behind); supraalar 2; scutellar two pairs. Thus the thorax has just 12 bristles on each side of the median line, the head three.

Scientific Notes

THE COTTON-WORM MOTH IN COLORADO. On the night of September 21, 1914, large numbers of moths appeared around the electric lights in Boulder, Colorado. Next morning, the night having been quite cool, hundreds of these insects were found resting on the ground in the vicinity of the lamps. Probably 90 per cent were *Heliothis obsoleta* Fab., and these consisted principally of var. *umbrosa*, with a sprinkling of var. *ochracea*. The other 10 per cent consisted mainly of *Alabama argillacea* Hbn., which I had never seen in Boulder before. There was a single fine specimen of *Erinnyis ello* L. The remaining moths appeared to be of local origin.

Although the specimens were remarkably fresh and perfect, they must have come at least 500 miles. *H. obsoleta* is a Colorado species, but the great numbers present, associated with the undoubtedly southern forms, can only indicate a migratory flight.—T. D. A. COCKERELL, Boulder, Colorado.

News Letter No. 4, of the Bureau of Entomology, is a roster of all officers and men engaged in the work of the Bureau. The number totals 207, divided as follows:

Administration	8
Deciduous fruit insect investigations	31
Cereal and forage crop insect investigations	33
Southern field crop investigations	19
Forest insect investigations	15
Truck crop and stored insect investigations	14
Apicultural investigations	5
Tropical and sub-tropical insect investigations	9
Miscellaneous	
Identification and classification	8
Health of man	12
Health of animals	3
Spread of moths	41
Field work	9
	207

ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The annual meeting of this Association and the sections on Apiary Inspection and Horticultural Inspection will be held at Philadelphia, Pa., beginning Monday, December 28, and extending through Wednesday, December 30, 1914.

An arrangement has been made whereby the annual meeting of the Entomological Society of America will be held on Thursday, December 31, and on Friday, January 1, 1915.

Members desiring to present papers should forward titles promptly on receipt of the regular notice concerning the meeting, which will be mailed by the secretary.

The general arrangement of the program follows:

Monday, December 28, at 1.30 p. m., opening session of the meeting of the American Association of Economic Entomologists. The regular business will be transacted and the address of the president will be presented at this session. At 8 p. m., the meeting of the section on Apiary Inspection will be held.

Tuesday, December 29, at 10 a. m. and 1 p. m., the regular sessions of the Association will be continued. Tuesday evening, at 8 p. m., the first session of the section on Horticultural Inspection will meet, and this will be followed by another meeting of this section at 10 a. m. on the following day.

Wednesday, at 1.30 p. m., the closing session of the Association will be held. Wednesday evening is left open temporarily, but in case the program is too long to dispose of at the sessions already arranged, papers will be presented at an evening session.

Thursday, December 31, at 10 a. m., the meeting of the Entomological Society of America will be opened, and another meeting of this society will be held at 1.30 p. m. At 8 p. m. the public address of the president of the Entomological Society of America will be given, and a smoker will be arranged by the entomological organizations of Philadelphia for all visiting entomologists.

Friday, January 1, 1915, the Entomological Society of America will hold its closing sessions.

A. F. Burgess,
Secretary.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

OCTOBER, 1914

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. The receipt of all papers will be acknowledged.—Eds.

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We hope in the next issue to practically clear up a number of papers which have been held for some months, owing to the necessity of giving precedence to the proceedings of the annual meetings. The Editor would add in further explanation that there has been an unusual amount of matter submitted for publication and, owing to our limited financial resources, only about so much could appear in each number.

We give on another page a brief note respecting one foreign serial. It is suspected that, owing to the war, some editors have been too busy to even send out an explanatory note. The gigantic struggle, with its accompanying waste of life, energy and resources, means a general and serious retrenchment in scientific work, especially among the nations most seriously involved. It is to be most earnestly hoped that the larger museums with their priceless treasures—their types and unpublished data—will escape the destruction that seems to have been the lot of some historical treasures. Even though this be the case, the imperative demand for men—a demand which will probably not be fully met in a generation—means the depletion of scientific staffs and the dropping by many of investigations which promise much for human welfare. We can all imagine the nearly finished manuscript laid aside, perhaps forever, and other papers held for years because of the sudden contraction in publication facilities—evident in the reduced size of numbers and possibly by the suspension of serials. We extend to our associates in the afflicted countries a heartfelt sympathy and we would voice the hope that there may be an early cessation of the deadly struggle and a speedy resumption of normal activities.

Reviews

Manual of Fruit Insects, by M. V. SLINGERLAND and C. R. CROSBY, xvi–503 pages, 396 text figures. New York. The MacMillan Company, 1914. $2.00 net.

Entomologists generally are to be congratulated that the unpublished notes and results of the studies of the late Professor Slingerland have here been put into permanent and usable form by Mr. Crosby.

The volume opens with a chapter of eight pages on general considerations in which are mentioned the vast amount of damage caused annually in the United States by fruit insects; their development; how they feed and how they may be controlled. Then follow concise accounts of the principal fruit insects, according to hosts, which in turn are listed in the order of their importance. Illustrations show the life stages of all the chief species. The space devoted to each kind of fruit is as follows: Apple insects, 204 pages; pear and quince insects, 29 pages; plum insects, 24 pages; peach insects, 38 pages; cherry insects, 11 pages; raspberry, blackberry and dewberry insects, 25 pages; currant and gooseberry insects, 22 pages; strawberry insects, 36 pages; grape insects, 63 pages; cranberry insects, 14 pages. The book ends with a chapter of 18 pages on insecticides, followed by an index of 11 pages.

The chapter on each food plant gives a brief account of the appearance, life history, injuries, and remedial treatment of each species, followed by a few references to the most important economic or descriptive literature.

At the end of each main division is a list of other insects also attacking that kind of fruit, each with a reference, to an account elsewhere in the book.

For the most part the treatment is clear and concise, yet comprehensive, thus including a vast amount of information between the covers of a moderate sized book. Most of the illustrations are from the well-known and excellent photographs of Professor Slingerland, though some have been furnished by others. Some are from pen drawings by Miss Anna C. Stryke. As a whole the figures are excellent and the volume is well-printed on good paper.

The work will be indispensable to all working entomologists and exceedingly useful to all farmers, gardeners and fruit growers. It is one of the series of Rural Manuals, edited by L. H. Bailey, and should find a place on the shelves of every agricultural and horticultural library.

W. E. B.

Current Notes

Conducted by the Associate Editor

Dr. H. E. Ewing has been elected assistant professor in entomology at the Iowa State College, Ames, Iowa.

The School of Agriculture, Purdue University, Indiana, now has 275 students taking work in entomology.

Mr. E. C. Cotton, assistant entomologist of the Tennessee Agricultural Experiment Station, has resigned to conduct a commercial orchard in Ohio.

Mr. A. L. Lovett has recently been promoted to the position of assistant professor in entomology at the Oregon Agricultural College, Corvallis, Oregon.

Mr. W. J. Schoene, who was recently appointed state and station entomologist at Blacksburg, Va., is now acting director of the Virginia Station.

Mr. G. F. Mozette, a 1914 graduate of the Oregon Agricultural College, has been appointed assistant in entomology at the Oregon Agricultural Experiment Station.

A fire, August 7, destroyed the entire equipment of the entomological department of the Agricultural Experiment Station (and College) at Stillwater, Oklahoma.

Mr. Tennyson D. Jarvis, associate professor of entomology in the Ontario Agricultural College at Guelph, has resigned to take charge of a fruit farm at Grimsby.

Mr. Frank E. Moeser, a collector and observer of lepidoptera, especially local Noctuidæ, died at his home in Buffalo, N. Y., May 15, at forty-five years of age.

Dr. Victor E. Shelford has recently been appointed associate professor of zoölogy in the University of Illinois on part time, and also biologist in the Illinois State Laboratory.

Professor G. M. Bentley, state entomologist of Tennessee and assistant entomologist of the station, has been appointed entomologist of the Station with Mr. H. R. Watts as assistant entomologist.

Dr. Charles C. Adams, of the University of Illinois, has been appointed assistant professor of Forest Zoölogy in the New York State College of Forestry at Syracuse University, Syracuse, N. Y.

Dr. C. Gordon Hewitt, Dominion Entomologist of Canada, inspected the field and parasite work on the gipsy moth and the brown-tail moth during the last week in June.

Mr. Loren B. Smith, a recent graduate of Cornell University, has been appointed assistant state entomologist of Virginia, and will be located at the Truck Crop Experiment Station at Norfolk.

Dr. W. D. Hunter, Bureau of Entomology, recently returned from a trip of inspection of the work in progress at Dallas, Texas, Tucson, Ariz., and in the Bitter Root Valley of Montana.

Mr. Thomas H. Jones, after an absence of some months for study in Washington, D. C., and Massachusetts, has returned to his former headquarters, The Sugar Producers' Experiment Station, Rio Piedras, P. R.

Mr. A. B. Duckett, Bureau of Entomology, has returned from a trip to New York and vicinity where he has been engaged in a preliminary investigation of the so-called "Argentine weevil."

Mr. E. Firmstone Heath, of The Hermitage, Cartwright, Manitoba, Can., died May 14, 1914, aged seventy-four years. Mr. Heath was a collector of insects, especially lepidoptera, and a frequent contributor to the *Canadian Entomologist*.

Mr. Russel Ferguson, assistant to the superintendent of moth work in Maine, with several assistants, is collecting parasites of the gipsy moth and the brown-tail moth for colonization in that state.

The following new men have been temporarily engaged by the Bureau of Entomology for work on the malarial survey at Mound, La. Ed. Foster, J. K. Thibault, Jr., W. W. Kimball and F. H. O'Neil.

Mr. D. E. Fink, Bureau of Entomology, has been engaged for some time on a new project—the fumigation of insects affecting stored products by means of ammonia gas. Considerable progress has been made.

Mr. Detmar W. Jones, a graduate of the Massachusetts Agricultural College, has been appointed scientific assistant, Bureau of Entomology, and assigned to parasite investigations at the Gipsy Moth Laboratory, Melrose Highlands, Mass.

Mr. E. O. Essig, Secretary of the State Horticultural Commission of California and Editor of the *Monthly Bulletin*, has resigned to accept a position in the entomological department at the University of California at Berkeley.

Mr. H. K. Laramore has been appointed field assistant, Bureau of Entomology, to work with Mr. High at Knox, Ind., in investigations of the onion thrips and other insects affecting onions and other vegetable and truck crops.

Mr. Leroy Childs, who for the past year has been assistant secretary of the California State Commission of Horticulture, has accepted a position as research assistant in entomology, at the Oregon Agricultural Experiment Station, Corvallis, Ore.

Mr. V. I. Safro, formerly assistant in the Bureau of Entomology, who recently resigned as assistant at the Oregon Agricultural College and Station, has been engaged as entomologist by the Kentucky Tobacco Product Company, Louisville, Ky.

Mr. H. B. Kirk, of the Bureau of Entomology, has recently accepted a position at the Laboratory of Economic Zoölogy, Harrisburg, Pa., where he will have charge of the photographic work and the breeding work of the insectary.

During the first week in June, Mr. A. F. Burgess visited the sections of New Brunswick and Nova Scotia which are known to be infested with the brown-tail moth, as the guest of Dr. C. Gordon Hewitt, Dominion Entomologist.

Mr. A. P. Sandles, Chairman of the Agricultural Commission of Ohio and Mr. N. E. Shaw, State Nursery Inspector of Ohio, spent several days in June investigating gipsy moth and brown-tail moth conditions in the infested area in New England.

Mr. Frank B. Herbert, of the University of California, has been appointed Entomological Ranger, Bureau of Entomology, to take effect November 1, and assigned to duty at the Pacific Slope Field Station at Placerville, California, under H. E. Burke, in charge.

The following new men have been temporarily engaged for tobacco hornworm demonstration work in Tennessee and Kentucky, by the Bureau of Entomology: O. M. Shelby, E. C. Crockett, A. D. Bosley, J. U. Gilmore, H. B. McKinney, F. G. Sorrels, R. K. Catlett, and J. E. McMurtrey.

Walter A. Price, a graduate of the Ohio State University, class of 1913, has been appointed assistant in entomology at Purdue University, LaFayette, Ind. Mr. Price entered upon his duties September 1. For the past year he has been assistant to Professor Osborn of Ohio State University, Columbus, Ohio.

Mr. John H. Pollock, of the Colorado Agricultural College has been appointed Entomological Ranger, Bureau of Entomology, to take effect September 1, and was assigned to duty at the Southern Field Station at Colorado Springs, Colorado, under W. D. Edmonston, in charge.

Mr. F. Paul Keen, of the University of California, has been appointed Entomological Ranger, Bureau of Entomology, to take effect August 1, and assigned to duty at the Pacific Slope Sub-Station at Ashland, Oregon, under John M. Miller, in charge of the station.

Mr. J. C. Evenden, of the Oregon State Agricultural College, has been appointed Entomological Ranger, Bureau of Entomology, to take effect October 1, and was assigned to duty at the Northern Rocky Mountain Field Station at Missoula, Montana, under Josef Brunner, in charge.

Mr. O. D. Ingall, a graduate of the Yale Forest School, who for several years was employed by the United States Forest Service, has been appointed assistant in Farm Management in the Bureau of Entomology and is conducting sylvicultural investigations in connection with the gipsy moth work.

Dr. Arnold V. Stubenrauch, who for several years has had charge of pomological investigations of the United States Department of Agriculture, and a member of the Federal Horticultural Board, has accepted a position in the University of California as head of the new division of pomology.

Mr. John E. Graf, Bureau of Entomology, who has been working on the potato-tuber moth, wireworms affecting sugar beet, and other insects affecting sugar beets and potatoes, with other members of the force of the Bureau, has removed from his old headquarters at Whittier to Pasadena, Cal.

Mr. Raphael Zon, Acting Chief of Forest Investigations in the United States Forest Service, spent several days in the gipsy moth infested territory examining the forest conditions with particular reference to the sylvicultural investigations which are being carried on coöperatively by the Bureau of Entomology and the Forest Service.

Mr. Carl Fuchs, one of the older entomologists of the Pacific coast and a well known Coleopterist, died June 11, at his home in Alameda, California, in his seventy-fifth year. For several years Mr. Fuchs was assistant curator of the entomological department of the California Academy of Sciences at San Francisco.

Mr. Lawson Caesar has been promoted to the position of associate professor; and Mr. A. W. Baker to that of lecturer; and Mr. G. J. Spencer to that of demonstrator, in entomology at the Ontario Agricultural College. All are graduates of the College, and have received the degree of B. S. A. from the University of Toronto.

Mr. L. S. McLaine, assistant to Dr. C. Gordon Hewitt, Dominion Entomologist of Canada, is stationed at the Gipsy Moth Laboratory for the summer. Mr. McLaine and three assistants are collecting parasites and natural enemies of the gipsy moth and the brown-tail moth for shipment to Nova Scotia and New Brunswick where an attempt will be made to colonize these species.

Dr. Henry H. Severin, who has been testing the poisoned bait spray to control the Mediterranean fruit fly and melon fly in the Hawaiian Islands, and the imported onion fly in Wisconsin, has accepted a temporary position with the Maine Agricultural Experiment Station to test out similar control measures against the currant or gooseberry fruit fly and the apple maggot or railroad worm.

The Review of Applied Entomology announces that in consequence of the state of war prevailing in Europe the July number of both series has not been dispatched and will not be dispatched to the United States until the British Post office is willing to accept them as free from risk. It has a large amount of material still in the office and continues to receive matter from the United States and there is no intention of suspending publication.

Beginning with the fiscal year 1915, a new project was undertaken by the Bureau of Entomology, namely, an investigation of the insects injurious to deciduous nursery stock, with especial reference to developing remedies and apparatus suitable for insect control under nursery growing conditions. Mr. A. J. Ackerman, of the Massachusetts Agricultural College, has been employed and assigned to this work, with headquarters for the present at West Chester, Pa.

Mr. E. R. Speyer of England, recently lecturer in economic entomology, and research officer in the diseases of trees to the Delegacy for Forestry at Oxford University, has been in the United States as a Carnegie scholar for the purpose of studying the larger problems in economic entomology, and particularly to study in the field with Dr. A. D. Hopkins the methods of controlling the Scolytidæ. Mr. Speyer has been appointed by the Ceylon Government to investigate the shot hole borer of tea in Ceylon.

Mr. Harrison E. Smith is engaged in work for the Branch of Cereal and Forage Crop Insect Investigations for the Bureau of Entomology and is located for the summer at the Gipsy Moth Laboratory, Melrose Highlands, Mass. Mr. Smith is collecting *Calosoma sycophanta* and *Compsilura concinnata*, two imported natural enemies of the gipsy moth that have become well established in New England, and shipping large numbers of these species to New Mexico where an attempt will be made to colonize them as enemies of the range caterpillar.

The office, laboratories and apiary of the investigations in bee culture of the Bureau of Entomology have recently been moved to Drummond, Md., where convenient quarters have been obtained in a residence of ten rooms, well adapted to office and laboratory uses. The lot contains about three fourths of an acre, well suited for an apiary. In the cellar will be continued the work on wintering bees, formerly carried on at the zoölogical laboratory of the University of Pennsylvania. For the present the bacterial work in apiculture will remain at the insectary of the Bureau. The new laboratory may be reached via the Wisconsin Avenue trolley line.

Mailed October 21, 1914.

DIRECTIONS TO BINDER.

In binding up full volumes of this magazine insert the opposite plate (Plate 9) to face page 340.